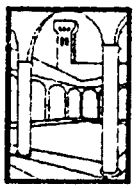

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Aurora Garcia Gallego

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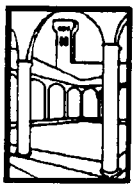

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Any errors are mine.

Contents

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Introduction

This thesis is the compilation of two independent parts. Part one investigates learning behaviour in oligopoly using experimental methodology. On the basis of a series of experiments[1], I analyse learning adjustment when firms act in an economic environment characterised by imperfect information about demand conditions. Furthermore, in this specific environment, the same market is repeated a finite number of periods and the factor in common between those markets is the fact that firms gain experience over time.

This part arrives at interesting conclusions concerning some questions often addressed by the economic literature on learning. The first problem is to test whether agents follow a learning rule in their decision making. The next question concerns the role played by factors like the quantity of information, the number of firms, the definition of firms' incentives and the product differentiation, in the firms' learning process. Finally, I check how those factors determine the probability that firms' strategies tend to converge either to the cooperative or to the non-cooperative equilibrium.

The results of part one do not agree with the conclusion of oligopoly theory that firms tend to the cooperative equilibrium as the game is played repeatedly, even if they do not cooperate explicitly.

The second part is a detailed study and discussion of a recent case of EEC competition policy that concerns Tetra Pak, one of the world leaders in the carton packaging for liquid food. Tetra Pak makes cartons for packing both fresh or non-aseptic and aseptic liquids.

This case arrived at the European Commission in 1983 and it is still un-

[1]These experiments were run through a local computer network and they are based in two programs written in Turbo Pascal. The programs are available on request.

der investigation. The 1991 decision of the Commission was the consequence of some information that seemed to prove Tetra Pak's anti-competitive behaviour. In its decision "Tetra Pak II" [1991], the EC Commission charged Tetra Pak with having taken advantage of its dominant position in the aseptic sector to commit abuses on the related sector of non-aseptics.

Part two investigates the Tetra Pak case under the prisma of dominance and tries to test the Commission's decision. Using empirical techniques and working with the information available from the Commission's decision, I arrive at some results concerning Tetra Pak's dominant position in one of the two sectors in which it participates, the non-aseptic. I test the hypothesis that Tetra Pak's dominant position in the non-aseptic sector is due to the firm's abusive practices in the other sector, the sector for aseptics.

The link between parts I and II is *learning*. In the first part, firms learn about other firms and the economic environment, whereas in the second part it is the environment - represented by competition authorities - that tries to learn about the behaviour of firms.

Part I

Experimental Evidence of Learning Behaviour in Oligopoly

I.1 Introduction

This part investigates learning behaviour in oligopoly using experimental methods. In particular, it focuses on the analysis of learning behaviour when firms have imperfect information about demand conditions. Trying to test learning behaviour, I ran a series of experiments that give some interesting results along the lines suggested by the literature on learning. More specifically, I focus on models in which the same oligopolistic market is repeated a finite number of periods and the only link between successive markets is provided by the fact that the agents acquire experience over time as the game is played.

Kirman [1975, 1983] and, later, Brousseau and Kirman [1991] put emphasis on the fact that agents act with limited and mis-specified models and that they try to learn from their experience about the precise specification of reality. Learning is put in a dynamic setting in which the outcomes observed by the agents are influenced by their actions and these actions may be influenced by the learning process. There are three main questions to answer in this type of scenarios. First, whether there is any learning process at all and if so, if there is any convergence of the learning process and how the convergence is influenced by such different economic factors as, say, the degree of differentiation between the products offered by the firms, the number of firms or the information available to them. Second, the extent to which firms are able to infer from their observations that they are dealing with strategic behaviour and if so how this would affect the convergence of the learning process. Third, to test the least squares method as a possible learning rule for the mis-specified model.

The present part aims at answering these questions. I run a series of

experiments in which I assume that firms have imperfect information about the specification of the market demand.

The next two sections make a brief review of the recent literature on learning in oligopoly and of the main contributions of experimental economics to oligopoly theory. Sections 4 and 5 discuss the economic model on which the experiments are based. Section 6 describes the organization of the experiments. The main results are discussed in section 7. The conclusions of this first part are presentend in section 8.

I.2 The Theory of Learning in Oligopoly

Based on the analysis of Cyert and DeGroot [1971, 1973, 1974] and Arrow and Green [1973], Kirman [1975] considers a duopoly problem in which firms are in error in the sense that they specify an incomplete model and add a random error term. Cyert and DeGroot [1971] analysed a duopoly in which one of the firms, which is not sure about the extent of its rival's willingness to match a price increase, establishes a prior probability distribution on the maximal price that may be matched. The firm then revises its distribution in the light of its experienced observations. In later work[2] and always in a duopoly, they analyse a situation in which each firm has a coefficient of cooperation, in the sense that each one of them maximises not only its own profit but also a fraction of the profit of its competitor. Each firm forms a *prior distribution* on the values of its rival's maximum level of cooperation. The process moves from a non cooperative equilibrium to a joint maximisation position. A different approach is suggested by Arrow and Green [1973]. They consider that firms

[2]See Cyert and DeGroot [1973].

make inferences about the true model they face. Their model has a *true* joint profit function for all firms and each firm has a *personal* model different from the true one. Cyert and DeGroot [1974] use a rational expectations model. According to their analysis, the equilibrium value of the economic model should coincide with the weighted average of firms' expectations about that value. In these models there may be no convergence at all, convergence to an equilibrium that is unrelated to the 'true' equilibrium, or, in specific cases, convergence to the true equilibrium. Kirman [1975] observes that[3]:

> "Provided the effect of the opponent's price is not too important in determining demand in the true model, the firms proceed by learning about an 'incorrect' model but arrive at a 'correct' solution."

The analysis made by Gates *et al.* [1977, 1978] introduces a different learning rule. The agents play a game with a minimum of information. Firms vary production levels according to the following adjustment process: each firm bases its new production decision entirely upon its knowledge of its own previous production levels and profits. It has no knowledge of its true payoff function. As a result, *"the market evolves towards an equilibrium state for any initial state"*. Furthermore, they conclude that *"all equilibrium states are characterised by the vanishing of the Jacobian of the payoff functions of the market game, and implies convergence to equilibrium"*. A common element of these analyses is that firms use specific rules for learning but these rules are not optimal since at any point in time their beliefs are revealed to be incorrect.

[3]This result is one of the main points of reference of the work presented here.

A later approach[4] assumes that firms choose their strategies as a continuous function of their competitors' previous period strategies to maximise their discounted infinite sequence of profits. Equilibrium may not exist in all cases.

The models which are used to describe oligopolistic situations should take into account the uncertainty in the structure of the economic system. This is pointed out in various ways by a number of authors. For example, Marcet and Sargent [1989] investigate a situation where the agents update their perceived law of motion by least squares. They apply the 'differential equation approach' but their framework fails to apply to models which have either hidden state variables or private information, as used in other studies of convergence of *least squares learning*. Kiefer and Nyarko [1989] go further on this line by using optimal control of a linear regression process with an unknown parameter, under an infinite horizon and discounted rewards[5]. They consider active[6] learning and convergence of beliefs. In general, for any action process they show that there will be complete learning of the true parameter if the action process does not converge, and there may be some (probably incomplete) learning if the action process does converge. Moreover, they show that the optimal action process converges[7].

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[4]See Friedman [1968, 1976] and Robson [1986] for more details. In a context of repeated games, Friedman and Samuelson [1990] focus on the matter of continuous reactions of players, but the scope of their analysis lies far from the aims of my experiments.

[5]See also Easley and Kiefer [1988].

[6]That is, a strategy which considers the information value of an action at each date.

[7]They show that it converges to the one-period optimal action under the long-run posterior distribution.

The hypothesis of players with a mis-specified model may help to overcome some of the limitations of those models involving learning in oligopoly. This is because players, after learning for a period, may reject the mis-specified model and come to a correct specification. Moreover, the learning process may or may not converge but it may be that the final situation is not the solution of the true model but it is self sustaining. As an example of this approach, Brousseau and Kirman [1991] considered agents with limited and mis-specified models in a dynamic setting. One difficulty of this approach is that the outcomes are influenced by other firms' actions and their own actions. Another difficulty is that actions may be influenced by the learning process. In their model, agents' strategies do not converge to any equilibrium. This is not only a problem of mis-specification, but also a problem of players' ignorance of the choice of the strategies played by their opponents. In other words, everything depends on the information available to the agents. This is explicitly expressed by Kalai and Lehrer [1992]. They require that, in order to have convergence to the Nash equilibrium, the truth should lie in the support of the agents' beliefs and that the support of those beliefs should be the same for all agents. Nyarko [1989] also studies a situation where agents have a mis-specified model and arrives at different results. He shows that, in the case of a monopolist maximising a sum of discounted profits facing a linear demand curve whose slope and intercept are unknown, actions and beliefs may cycle on every sample path. However, such behaviour is not possible if the agent's model is *correctly* specified and, in that case, actions and beliefs necessarily converge.

As a result, there are definitely some facts that remain to be studied regarding learning by agents. Among the most important of them, I suggest

the amount of information that agents have concerning their environment, the objective function of the agents and, finally, the learning rule they use.

I.3 Testing Learning Behaviour

Experimental economics started in the 80's as one of the most interesting methods to empirically test the results of economic theory. The use of laboratory experimental methods in economics has developed into a powerful instrument of applied microeconomics. In particular, experimental methods have been applied to economic situations like imperfect competition and oligopoly[8]. Plott [1982] made experiments in monopoly to analyse the importance of the form of the market organization within which buyers and sellers interact, in determining market performance[9]. He concluded that market structure and the institutional environment are dramatically important.

By using oral auctions, Smith and Williams [1981] arrived to the conclusion that it is really difficult to reach any general conclusions about the comparative accuracy of the models. One of the results they reach is that when monopolists post prices, market behaviour is accurately captured by monopoly theory.

Oligopoly theory has also been tested by experiments. One of the main results is that a harmony of interest is not easily recognizable by oligopolists, and that perhaps agents automatically treat competitive situations as zero-sum games so that certain collusive outcomes predicted by oligopoly theory

[8]See Plott [1982], Smith and Williams [1981], Holt [1985] and Alger [1987].

[9]See also Smith [1976] and Plott [1979].

never occur[10].

Early experiments in oligopoly give subjects a profit table or its functional equivalent. The table contains the agents' profits expressed as a function of his/her own price and the price of a competitor. This removes all strategic behaviour from the picture. Demand data privately held by buyers are revealed to the seller. Four main conclusions are reached[11]. First, that full information about payoffs, symmetric payoffs, full information about opponents' choices, and very long periods of interaction tend to facilitate collusive behaviour. Second, prices higher than the competitive ones are observed. Third, the consistent-conjectures equilibrium and not the Cournot equilibrium is the principle behind the observed behaviour[12]. Fourth, the upward bias of price posting occurs even when a large number of competitors exist. Posted prices facilitate the maintenance of prices at higher than competitive equilibrium levels but do not guarantee it[13].

The theoretical origin of a series of applied analyses[14] on learning is to be found in Brousseau and Kirman [1991]. They analyse the dynamics of

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[10]See Plott [1982].

[11]See Plott (1982).

[12]This is asserted by Holt [1985]. He specifies a consistent-conjectures equilibrium by using Bresnahan's [1981] condition of consistency in a homogeneous-product duopoly in which quantity is the strategic variable, variable costs are zero and industry demand is linear. He explains that, although not explicitly dynamic, the consistent-conjectures equilibrium approach is plausible because it predicts deviations from a static Cournot-Nash equilibrium that are qualitatively consistent with the data reported in several published laboratory experiments with university students being the 'subjects'.

[13]See Alger[1987].

[14]Through experiments and through simulations.

learning in mis-specified models. This work is the starting point in testing situations in which agents are uncertain about their demand curve. One of the problems to be solved is the role of ordinary least squares[15] in the presence of uncertainty. One way of estimating the relation between two or more variables is to apply the method of least squares. Therefore, it makes sense to test if agents do actually use the least squares method in order to get additional information about the market. From a theoretical perspective, the conclusion in Brousseau and Kirman [1991] is that least squares learning is not stable. Even if agents' ideas of the uncertain parameters change as time goes by, they may not converge to any equilibrium. In the same line, Kiefer and Nyarko [1989] show that optimal policies are different from the least-squares policies and, thereafter, suggest an improvement over least-squares.

Closer to the analysis presented here, Chautard and Raby [1991] make an applied study about a specific model of demand in which players have imperfect information about demand and each player knows nothing but his/her own past. They also run a couple of experiments in which an artificial player plays againts human subjects. This artificial player fixes its strategy based on an algorithm that they describe as a good approach to a 'clever attitude'. They explain that *"of all equilibria obtained in the theoretical Brousseau and Kirman analysis, only the Bertrand-Nash solution appears to be the limit point for prices fixed by human beings"*. Concerning the method used by agents to fix their strategy, they note, *"the experimental sessions, in which players refused to apply the ordinary least squares method, have proved that it is not only adequate but also necessary for them to be free to fix prices by following a specific algorithm. It is convenient not to abandon totally the idea that*

[15]Also referred to as OLS or as the least-squares method.

players apply the method of tâtonnement".

Always on the basis of the Brousseau and Kirman [1991] model, Hopkins [1992] runs simulations trying a variety of learning algorithms, for the case of more than two firms and also looking at the least-squares learning with limited memory. On the OLS, the Brousseau and Kirman findings are, in general, confirmed. Prices do not converge to Nash equilibrium levels. Moreover, he analyses the human behaviour observed in some experiments where all agents seem to approach fairly close to the Nash equilibrium price. He even introduces an algorithm that mimics that behaviour.

Another question going in the same direction is whether or not agents consciously show a strategic behaviour in inferring information, so that they may be able to change some mechanisms in the market and, maybe, converge to the optimal strategy. Do firms really behave strategically or do they just try to learn from the strategies of the past?

Going beyond the work of Brousseau and Kirman [1991], I test here learning behaviour in an oligopolistic market with product differentiation. Players know the results (own demands and profits) of their strategies and the strategies of their rivals in the past. The test is based on five experiments with the use of a computing laboratory.

The economy is characterised by demand mechanisms that are not known by firms. Following the terminology used by Kirman [1975], I consider that there is a model which is a function of the firms' decisions every period. This model governing the demand is called the 'true model'. The true model tested here is an oligopoly model with product differentiation.

I have run a number of oligopoly experiments to test the relevance of equilibrium in oligopoly models. Some experiments have indicated that economic

theory is not necessarily the only way to explain human behaviour even when the agents are aware of the concepts of game theory. Despite the critical attitude of some economists towards experimental economics[16], I agree with Plott [1987] in that the role of experiments is to provide the foundation for making 'educated guesses'. The purpose of experiments is to make the guess, in the light of experience, as informed as possible.

I.4 The Model

There are n firms, offering a differentiated product during T periods. Price is the only decision variable of each firm at each period.

Firm i's demand in period t is given by:

$$q_{it} = \alpha - \beta p_{it} + \theta \sum_{j \neq i}^{n} p_{jt} \tag{I.1}$$

where parameters α and β represent, respectively, the intercept and the slope of the demand function. Both are fixed and constant[17]. In the experiments, the values of these parameters are $\alpha = 500$, $\beta = 3$. The parameter θ indicates the effect of a firm's rivals' prices on the firm's demand[18]. In

[16]Part of the critiques are based on the artificiality of the experiments, on the characteristics of the participants and on the consequences of friendship between players for the results obtained from the experiments. It can be argued that economic theory is not free from similar problems.

[17]This model could similarly be written as: $q_{it} = \alpha' - \beta(p_{it} - c) + \beta\theta' \sum_{j \neq i}^{n}(p_{jt} - c)$, where prices are expressed as deviations from marginal cost with $\alpha' = \alpha - c[\beta - (n-1)\theta]$ and $\theta' = \theta/\beta$.

[18]$\theta = 0.14$ in experiments 1,2,3 and 5. $\theta = 0.4$ in experiment 4.

other words, it measures the degree of substitutability between the varieties produced by different firms.

The variety produced by each firm is technically similar to the rest of the varieties produced by the rest of the firms[19]. Firms are assumed to produce exactly what they can sell. I assume constant unit costs, c_i, which are common for all firms. In the experiments I set $c_i = c = 40$ monetary units.

The profit Π_i of firm i in period t is given by:

$$\Pi_{it} = (p_{it} - c)q_{it} \tag{I.2}$$

The procedure of the game is as follows: in each period t, firms decide their prices simultaneously and independently. At the beginning of each period, each firm updates its information with last period's own demand and profit as well as the prices fixed by the firm's rivals. All firms are equally informed about the rules of the game. The game is repeated a finite number T of periods.

I.5 Equilibria

There are two types of equilibria for this model, the *non-cooperative* and the *tacitly cooperative* one.

I.5.1 The Bertrand-Nash Equilibrium

The non-cooperative solution of this game corresponds to the Bertrand-Nash equilibrium which is unique and equal to:

[19]Which implies equal unit cost for all firms.

$$p_{it}^{*} = \frac{\alpha + \beta c}{2\beta - \theta(n-1)} = c + \frac{\alpha - \beta c[1-(n-1)\frac{\theta}{\beta}]}{\beta[2-(n-1)\frac{\theta}{\beta}]} \tag{I.3}$$

for $i = 1...n$ and $t = 1...n$. The non-cooperative solution concept requires that each period t every firm maximizes its profit, given by equation (2), taking the decisions of the other firms as given. It corresponds to the best response of each firm to the decisions of the other firms.

Equilibrium profits that result from the non-cooperative solution are given by:

$$\pi_{it}^{*} = \frac{\beta[\alpha - c(\beta - \theta(n-1))]^2}{[2\beta - \theta(n-1)]^2} = \beta[p_{it} - c]^2 \tag{I.4}$$

I.5.2 The Joint Monopoly Equilibrium

The tacitly cooperative solution is given by the joint monopoly equilibrium which is:

$$p_{it}^{*} = \frac{\alpha}{2(\beta - \theta(n-1))} + \frac{c}{2} \tag{I.5}$$

This equilibrium supposes that firms act as a sole firm that produces n different varieties, so that each firm maximizes the total profits of the industry.

Profits in the joint monopoly equilibrium are given by:

$$\pi_{it}^{*} = \frac{[\alpha - c(\beta - \theta(n-1))]^2}{4[\beta - \theta(n-1)]} \tag{I.6}$$

I.6 Experimental Design and Organization

I organized five experiments at the Experimental Laboratory[20] (LeeX) of the Universitat Pompeu i Fabra in Barcelona (Spain). The players were students of that University[21]. All of them were economics students, with a clear majority of students from the third and fourth years of studies. It makes sense to assume that, to some extent, all players had some knowledge of oligopoly theory. No student played in more than one experiment.

The experiments were based on two programs written in Turbo Pascal, one for the players and one "master" program that controlled the whole economic system.

Table A contains a brief description of the experiments. The number of firms - n -, the degree of product differentiation - given by parameter θ -, the information of firms - perfect, if they know the model of demand and the value of all parameters, and imperfect otherwise -, the mode in which agents were rewarded and the number of periods, are given for each experiment[22].

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[20]This laboratory is used exclusively to run experiments.

[21]To recruit players, a "call for volunteers" appeared a few days before each experiment in the hall of the Faculty of Economics and Law of the University. The announcement included information about the number of experiments, the duration of each one of them and the name of the organizer. Volunteers were asked to give the number of their identity card, their telephone number and sign down in a number of lists at the entrance of the experimental laboratory (it is used exclusively to run experiments). There was no talk of pregame collusion. The number of volunteers and their punctuality were remarkably high.

[22]Since firms are uncertain about demand and given that changes in other firms' strategies have a big effect on each firm's demand, by choosing small values for parameter θ I intend to avoid increases in firms' uncertainty that could be an obstacle to the learning process.

TABLE A

Description of the Experiments					
	Ex. 1	**Ex. 2**	**Ex. 3**	**Ex. 4**	**Ex. 5**
Firms	$n = 5$	$n = 5$	$n = 5$	$n = 5$	$n = 3$
θ	$\theta = 0.14$	$\theta = 0.14$	$\theta = 0.14$	$\theta = 0.4$	$\theta = 0.23$
Inform. demand	Imperfect	Imperfect	Perfect	Imperfect	Imperfect
Reward	mode A	mode B	mode A	mode A	mode A
N. of periods	$T = 20$	$T = 20$	$T = 20$	$T = 20$	$T = 15$

Agents were paid at the end of each experiment. I used two different modes of reward[23].

Mode A consisted of a quantity equal to the equivalent of a firm's accumulated profits multiplied by an equivalence factor of 0.01 pesetas for each unit of accumulative profit along the T periods.

Mode B consisted of a fixed quantity of 1000 pesetas plus an additional quantity calculated as a function of a firm's accumulated profits. The proportion was calculated on the basis of an equivalence factor of 0.006 pesetas for each unit of accumulative profit. Additionally, a quantity of 1000 pesetas was distributed proportionally between the two firms with the highest accumulative profits along the T periods.

[23]Merlo and Schotter [1992] emphasise the importance of the method of reward for the results of an experiment. With reference to Harrison [1989], Merlo and Schotter [1992] explain that the expected payoff function can influence the behaviour of subjects. In general, they remark this fact comparing a situation in which agents' rewards depend on their accumulated profits, with a situation in which these agents' reward depend just on the profit they make in the last period. I have not considered this last alternative of reward in my experiments. My conjecture is that it would result in agents behaving irrationally or putting all effort on their learning until they arrived at the last period.

In principle, mode A rewards each unit of profit more than mode B. On the contrary, mode B is chosen to reward and encourage firms' efforts to do better than their rivals[24].

Each one of the five experiments was technically organized as follows:

1. There are $n = 5$ players in experiments 1-4 and $n = 3$ players in experiment 5.

2. Each player represents a firm in an industry.

3. Firms produce a differentiated product during T periods[25].

4. Each player sits in a separate cubicle with a personal computer.

5. All computers are connected through a local area network.

6. On a supplementary computer in this network, the master program is installed and controlls the whole experiment.

7. Each player independently chooses his/her price for each period which is then transmitted to the master program.

8. The master program reads the information and calculates demands and profits that correspond to the chosen prices.

9. The master sends back to each player's screen the information on demand, profits and other players' actions in the previous period.

10. With this information, players start the next period and decide on their next strategy.

11. The screen offers each player a *'main menu'* that can be used to call

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[24]This way of rewarding agents is the line of a manager's behaviour. The spirit of a firm's manager aims at making of its firm the best firm of the industry.

[25]In experiments 1-4, firms know a priori that the number of periods that the industry exists is $T = 20$. Only in experiment 5 firms are told that the industry may end at any time.

up information on past periods' prices of other players, own demands and profits.

In each period, players were given a total of two minutes and a half to make their decisions. Within this interval of time, players could make any modification of their price decision. A clock on each player's screen indicated the time passing.

Before the beginning of each experiment, players were given instructions on the technical functioning of the game although there was no preliminary play. Immediately afterwards, a sheet of paper containing the characteristics of the economic scenario simulated by the game and the instructions to follow were given to the players[26].

When every player was sure to understand what the game was about, all screens were set at the 'main menu' which, among other information, indicated that the first period was already running.

This is how the 'main menu' - screen looks like:

[26]The appendix contains a copy of the instructions given to the players in each experiment.

00 : 02 : 00

Main menu

Period number :1

Price :

You can fix a new price with :	"1"
You can use some help-facilities:	
Summary of prices, demands and profits :	"2"
Own prices and demands in a graph :	"3"
Own prices and profits in a graph :	"4"
Ordinary Least Squares estimation of demand :	"5"
Prices of other firms in the past :	"6"

A number on the right of an option indicates the key that should be pressed in order for the option to be used. To fix a price, players had to choose **option 1** on the keyboard. Players had an unlimited possibility to change their decisions before the end of each period.

At the end of each period, the message:

"Your price for period 't' is : 'p_{it}'

Please wait until the beginning of next period"

appeared on player i's screen, where p_{it} indicated the player's choice for the t'th period.

A few seconds later, the next period would start. **Option 2** of the main menu gave each player his own **demands** and **profits** in past periods. Firms could use **option 6** to learn the **prices set by all other firms** in the past.

Therefore, each firm could use a rule of three to learn the evolution of demand and profits for each one of its rivals. However, this would imply that

players were expecting to have the same true model, which is not obvious in any sense.

Players were offered additional information through a number of graphs. **Options 3** and **4** offered each player a plot of his/her **own profits** and **demands**[27] againts the player's corresponding pricing decisions. **Option 5** offered each player an **OLS estimation** of a demand function based on the observations of demand and prices of the firm in the past.

Players were offered perfect information on the mode of payment that corresponded to the experiment in which they were taking part.

Table B presents Bertrand and joint monopoly equilibrium prices, demands and profits for the five experiments :

[27]That correspond to the true demand function.

TABLE B

Equilibria			
	Parameters	**Bertrand-Nash**	**Joint Monopoly**
Experiment 1	$n = 5$ $\theta = 0.14$ $T = 20$	$p_i = 114$ $q_i = 221.8$ $\Pi_i = 16413$	$p_i = 122.5$ $q_i = 201$ $\Pi_i = 16582$
Experiment 2	$n = 5$ $\theta = 0.14$ $T = 20$	$p_i = 114$ $q_i = 221.8$ $\Pi_i = 16413$	$p_i = 122.5$ $q_i = 201$ $\Pi_i = 16582$
Experiment 3	$n = 5$ $\theta = 0.14$ $T = 20$	$p_i = 114$ $q_i = 221.8$ $\Pi_i = 16413$	$p_i = 122.5$ $q_i = 201$ $\Pi_i = 16582$
Experiment 4	$n = 5$ $\theta = 0.4$ $T = 20$	$p_i = 140.9$ $q_i = 302.7$ $\Pi_i = 30542$	$p_i = 198.6$ $q_i = 222$ $\Pi_i = 35209$
Experiment 5	$n = 3$ $\theta = 0.23$ $T = 15$	$p_i = 112$ $q_i = 216$ $\Pi_i = 15552$	$p_i = 118.7$ $q_i = 199$ $\Pi_i = 15661$

Observe that, in experiment 4, a higher value of θ results in a higher equilibrium price, demand and profits as compared to experiments 1-3 where varieties are more differentiated. The reason is that a higher θ is translated in higher strategic complementarity, in the sense that a more aggressive[28] strategy by the competitors raises a firm's marginal profit.

In experiment 5 there are three firms instead of five[29].

[28] In the sense of charging high prices.

[29] I set $\theta = 0.23$, so that a unit price increase by a firm's rivals in this experiment has the same effect as a unit price increase in experiments 1, 2 and 3. Note that $0.14 \cdot 5 = 0.23 \cdot 3$.

My goal is to study learning adjustment. I try to test whether the market evolves towards an equilibrium and, if so, how firms' strategies tend to converge to any equilibrium strategy - joint monopoly equilibrium or oligopolistic Bertrand-Nash equilibrium. I analyse the importance of the level of differentiation between goods, the number of firms, number of periods and availability of information in determining market performance.

I.7 Experimental Results

Tables 1 to 5 (Appendix 2) present prices, demands and profits for each firm in each period in the five experiments.

Before examining convergence criteria as well as the existence of learning in this game, it is worth paying attention to some details observed during the experiments and that may have influenced the results. Apart from their own demand and profits, players were observed to use the table of prices fixed by the rest of the players in the past as one of the main sources of information before deciding on the strategy of the next period[30]. One consequence of such behaviour was that some players followed a tâtonnement process in their decision making[31]. Another consequence was that some players fixed exactly the same price as the one fixed by their rivals in the past. For example, in experiment 4, player 2 confessed to be following the signals of player 4 over all periods because she was convinced of the positive effect of those signals

[30]This behaviour reasonable since the prices are sometimes the only information available to firms on their rivals' behaviour.

[31]However, this was not the general rule in any of the experiments.

on her final ranking[32].

A phenomenon that occurred especially in the first periods is that some players did not take into account that the time was passing and sometimes this resulted in prices below the marginal cost[33] or even in negative prices[34]. None of them can be considered as firm decisions. However, the most striking example was observed in experiment 4 in which firm 3 charged a price of -3960 for period 14. This is treated as a profit reducing shock in the market. After the shock, no firm returned to the price fixed in period 14. Moreover, all firms, except for firm 4, reacted setting a higher price in period 15 than the price they had charged in period 14. Aware of their loss in the previous period, they wanted to compensate it by increasing profits more quickly. The interesting feature of this situation was that they had thought the same thing at the same time, which was the only way of having a positive result.

As far as strategic behaviour is concerned, in all experiments there were players that charged the same price over 2 or 3 periods as a mechanism of

[32]Players could not see each other's profits, just prices. Therefore, players profits were not being ranked but she was concerned. Observe that this effect is also important in experiment 5 for firms 2 and 3 in periods 2-3, 7-8 and 10-11.

[33]As it happened in experiment 2 to firm 3 in period 3, and to firm 3 in period 1 in experiment 5. They charged prices of 5 and 0 respectively.

[34]In experiment 5, firm 3 fixed a price of -1 in period 1. A way to avoid this kind of problems might be found in a message saying: *'You have fixed a negative price. Please change your decision'* that could appear on the screen of the player that fixed a negative price. The problem is that players had two minutes and a half to make changes in their price, and only the price charged at the end of that time was considered a real decision of the player. At that time, any message would have interrupted the normal run and coordination between the rest of the players.

studying the effects of other players' strategies on their profits and demands. This is observed, for example, in experiment 1 for firms 2 and 5, in periods 1-3 and 15-17 respectively, or in experiment 2 for firms 2, 3 and 5, in periods 17-19, 13-15 and 17-19 respectively. In addition, in experiment 4 player 4 was trying to control the decisions of all other firms[35]. In particular, he was signalling to the others in order to make them believe that, for example, increases in his price were not followed by decreases in his profits and that his decision to increase price again in the next period was not punished with low profits. Player 4 said that he preferred to do this 'signalling' even if this could imply a sacrifice of a part of his profits. However, he said, 'I took these decisions with a lot of care not to lose too much of my profits so that I could still be the 'best' at the end of the game'. He added that, even if he understood clearly the way of rewarding the participants in that experiment, he 'had learned from other experiments that to be the best was always rewarded in one way or another'. In the early experimental literature, we find the idea that subjects' experience from previous rounds or experiments affects the final outcome[36]. However, experience in experiments is obviously not the same as experience in the real life situation that an experiment is supposed to represent, and the behaviour of player 4 is a good evidence of that.

[35]When players came to receive their payment for their participation in the experiment, I asked them if they were following any specific strategy and, if so, what strategy and for what reasons.

[36]See Benson and Faminow [1988] and Keser [1990].

I.7.1 Convergence

Figures 1-5 show prices set by the players along the twenty periods[37] in the five experiments. Each figure includes a graph showing the evolution of prices over the last fifteen periods[38].

In the figures, the Bertrand-Nash equilibrium price is denoted by B and the joint monopoly one is denoted by m. Firms tend to charge over time prices closer to the Bertrand-Nash solution than to the joint monopoly one. A process of convergence to the Bertrand-Nash equilibrium can be observed[39]. In experiment 1, four firms charge, in the last period, prices below but close to the Nash equilibrium, while the other fixes a price above but closer to the Nash solution than to the joint monopoly one. This is shown in Figure 1. Plott's [1982] result seems to be confirmed here: *"When there is imperfect information about actions or payoffs, prices converge to near the non-cooperative equilibrium"*.

With the introduction of mode of reward B, players had an additional incentive to be the firm with the highest accumulative profits. Thus, one would expect more competition between firms and therefore a clearer tendency to the Bertrand-Nash solution. On the contrary, this new characteristic in the market resulted in a process that approaches - but does not converge - to the joint monopoly price on the part of all firms. In experiment 2, it is ob-

[37]Fifteen in the case of experiment 5.

[38]The figures that represent the corresponding evolution of profits for each experiment can be found in the appendix.

[39]Since the number of periods is limited to twenty, I can not refer to 'convergence' in a strict sense. I refer to a situation in which observations get closer to a limit point as time goes closer to the last period.

served in Figure 2 that, from period 15 on, all firms charge prices above the Bertrand-Nash price. At the end, in period 20, three firms are above but closer to the Nash equilibrium price and two firms are closer to the joint monopoly equilibrium price. This may be due to imperfect information and the 'naive' belief that one can earn more by simply charging higher prices. Compare Figures 1 and 2. It is interesting to observe the effect that such naive beliefs have on the level of profits. Observe Figure 7 (Appendix 2). Profits are actually converging to the joint monopoly equilibrium. Even if prices are, in general, closer to the non-cooperative equilibrium price, firms end up earning profits that correspond to a collusive situation. The fact that one of the players - player 5 - sets very high prices over all periods results in making profits of all players increase. Therefore, the four firms earn the profits that they would earn under collusion by charging prices close to the Bertrand-Nash equilibrium.

Figure I.1: **Prices. Experiment 1**

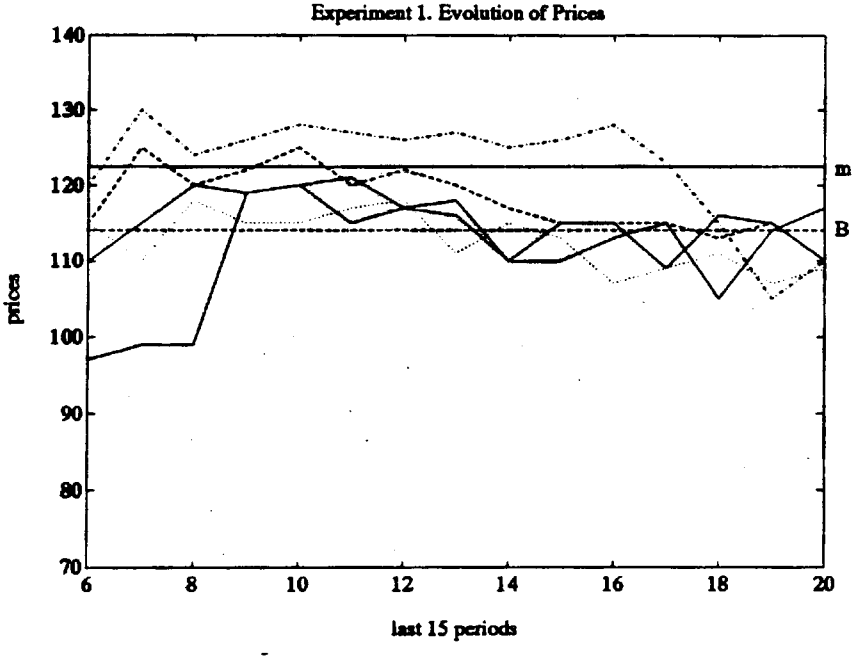
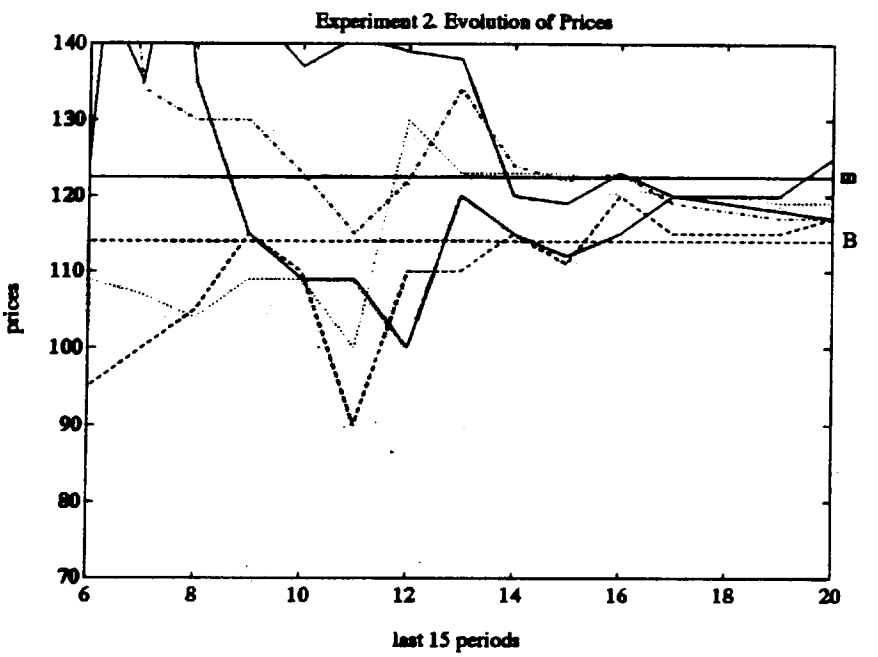


Figure I.2: **Prices. Experiment 2**

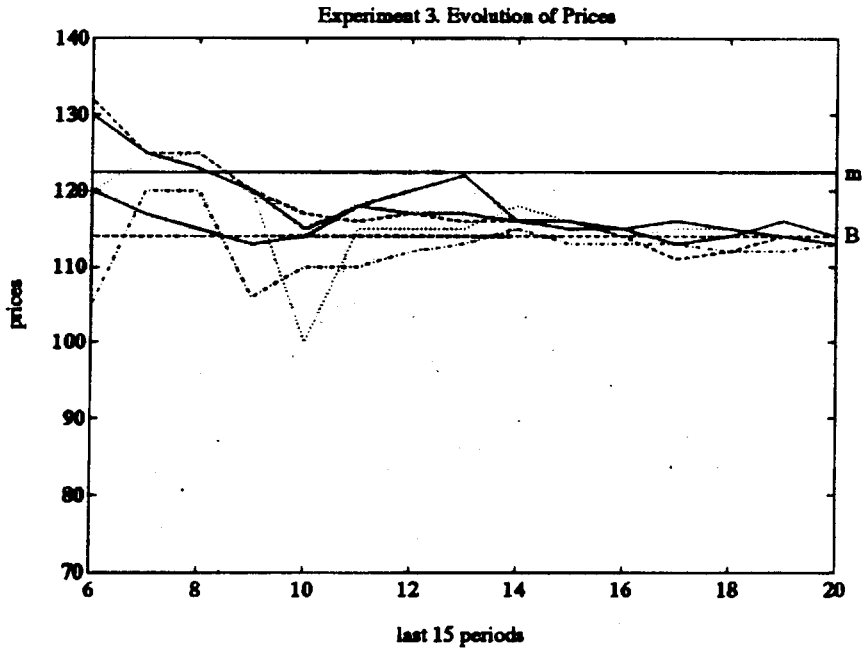


It has been said that many convergence results depend very much on whether players know the true model or not. In experiment 3, firms had perfect information about the true model and the values of the parameters. It makes sense to assume that agents did know how to compute the appropriate equilibrium and some of them actually did calculate the price that would maximise their profits taking their rivals' actions as given. The result is that the process has a tendency towards the Bertrand-Nash equilibrium since period 10 and that, in fact, there is convergence to the Bertrand-Nash equilibrium price. See Figure 3.

However, no trace is found of the 'tendency to higher than the one shot non-cooperative equilibrium prices' mentioned by Plott [1982]. The evidence obtained from experiment 3 does not confirm Plott's [1982] findings when he notes two of the prominent features of the experimental literature on oligopoly and price posting: *"full information about payoffs, symmetric payoffs, full information about opponents's choices, and very long periods of interaction tend to facilitate collusive behaviour"* and *"higher than competitive prices are observed in oligopoly experiments"* [40]. An explanation of the disagreement between Plott's results and the ones obtained here may be that 20 periods were not enough for collusive behaviour to be developed. However, note that prices were already converging to the non-cooperative equilibrium price since period 14. This means that over the last six periods prices were moving around the non-cooperative solution and no tendency to go towards the collusive price was shown.

[40] Friedman and Hoggatt [1980] and Alger [1986] all provide evidence in this direction.

Figure I.3: Prices. Experiment 3



Another hypothesis that is tested is whether the process of convergence is different for different levels of competitive pressure in the market. The evidence from experiment 4 is that, as the value of θ increases[41] and, therefore, strategic complementarity becomes stronger - more aggresive strategies of a firm's rivals result in a higher marginal profitability of the firm's own strategies[42] -, convergence to the Bertrand-Nash equilibrium is more likely. See Figure 4.

The mistake of firm 2 in period 14 to charge a negative price of -3960 is treated as a profit-reducing exogenous shock. However, the trend of prices before this shock does not seem to change after that period. On the contrary, firms continue increasing prices with a tendency towards the Bertrand-Nash equilibrium. In period 20, firm 2 charges exactly the Bertrand-Nash price, firm 5 is below but close to it and the other three firms fix prices above but closer to the Nash than to the joint monopoly equilibrium price.

In general, prices are far from the joint monopoly equilibrium price and the increasing trend of prices is observed to disappear as prices get closer to the Bertrand-Nash equilibrium.

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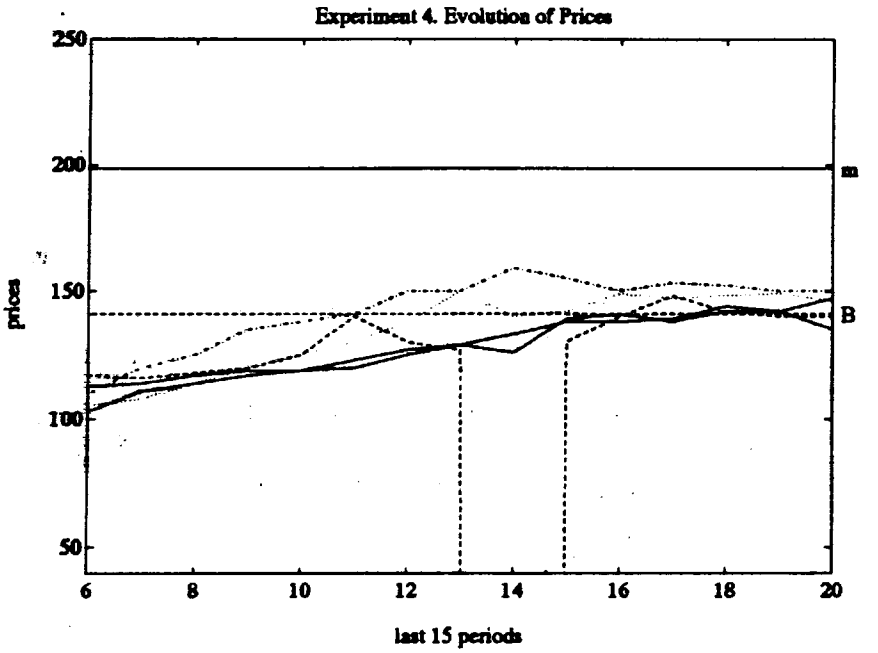
[41]Remember that $\theta = 0.4$ in experiment 4 as compared to $\theta = 0.14$ in previous experiments.

[42]This definition of strategic complementarity follows Bulow *et al.* [1985].

Figure I.4: **Prices. Experiment 4**

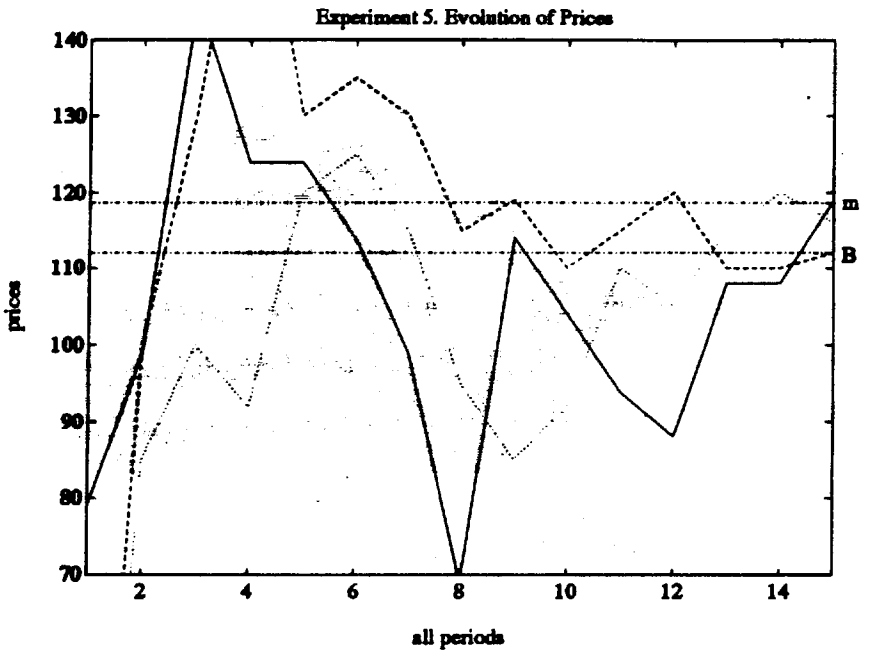


At the beginning of each one of the experiments 1 to 4 players knew that they were going to play during 20 periods. This might have affected their behaviour. For example, a player might react less competitively to other players' decisions if he/she knew that there were still many periods to go. In the last experiment, I did not inform players on the number of periods that they were going to play. The industry, for any reason, could 'close' at any moment. This 'any moment' resulted to be period 15[43]. Three firms were competing this time. Firm 2 ended with the Bertrand-Nash equilibrium price while the other two were very close to the joint monopoly price. See Figure 5. With less firms competing in the market and, therefore, more possibilities for 'signaling' and less competitive pressure, convergence to the joint monopoly equilibrium becomes more likely, even in the presence of uncertainty about the repetition of the game.

It seems that firms want to sacrifice a part of their profits in the present to signal their rivals that they do not intend to engage in competition and encourage them to set high prices and reach the joint maximisation point tacitly.

[43]There are two reasons why I chose period 15 to be the last period. One reason is that it had to be a period different from period 20, to avoid any players' expectations created by information from other players that played in the other experiments. The other reason is that, by observing players' decisions along the experiment, I noticed that, from period 12 on, players were already fixing prices around the non-cooperative equilibrium price.

Figure I.5: **Prices. Experiment 5**



Let us remember one of the main conclusions of Arthur [1990] which asserts that *"the question of whether human behaviour adapts its way to an optimal steady-state*[44]*, or a Nash outcome admits no simple yes or no answer. The answer depends on the problem"*. The obvious truth of this assertion seems to apply also here. As Arthur [1990] explains, how long it takes to uncover 'reasonable' or optimal choices depends upon the degree to which payoffs are tightly clustered[45]. There is what he calls *'characteristic learning time'* for human decisions in the economy that depends on the frequency of observed feedback on actions taken and on the payoff structure of the problem itself. The experimental data presented here can be considered as a confirmation of Arthur's [1990] assertion. Since the economic environment of the decision problem remains constant, the learning time seems to be shorter than the problem horizon and convergence to equilibrium is expectable.

I.7.2 Learning Algorithms

The main question that I try to answer with this series of experiments is how firms proceed with their *learning about the true model.* One difficulty in learning about the structure of the model is that the observations which are used to learn from are themselves influenced by the actions of the players. The other difficulty is that there is a trade-off between gaining information about the model and short-run profit. Trying to maximise the sum of the flow of profits without knowing the complete specification of the model, players

[44]In the sense of concentrating on the best option.

[45]He developed a calibrated iterated-choice algorithm which showed that human learning can lock in to an inferior choice, and that this is prone to happen where payoffs to choices are closely clustered, random and, therefore, difficult to discriminate among.

face a quite complicated problem.

The model includes three parameters - α, β and θ - that are unknown to the firms. The role of maximisation of profits just for one period is not negligible. One way to act in the short run could consist of fixing prices which give a low immediate profit but which, in the long run, give more information about the structure of the model.

It is remarkable that players did not simply use a tâtonnement method. Out of few exceptions, players kept on an specific behaviour that is described below[46].

I already mentioned Hopkins' [1992] algorithm concerning the mimicry of the human behaviour observed in a series of experiments[47]. In particular, the participants in his experiments changed prices in what Hopkins believes is the 'right direction' by an arbitrary amount:

$$p_{it} = p_{it-1} + t^{-\nu} \cdot \omega_t \cdot sign \left[\frac{\pi_{it-1} - \pi_{it-2}}{p_{it-1} - p_{it-2}} \right] + \epsilon_t \qquad \text{(I.7)}$$

where ϵ_t is distributed as a $N(0,1)$ and ω_t is a random variable distributed uniformly on (0,20). That is, "if a price cut (hike) raised profits the previous period, another price cut (hike) (of size $[t^{-\nu} \cdot \omega_t + \epsilon_t]$) follows".

That algorithm is observed to be followed by some of the agents of the experiments presented here. In some cases, I find that some of the participants

[46]In those few cases, however, series of prices resulted in white noise models which are stationary stochastic processes ($p_{it} = \delta + \epsilon_{it}$, where δ is the average of the process and $\epsilon_{it} \rightarrow N(0,1)$).

[47]Hopkins [1992] works with data obtained from Chautard and Raby's [1991] experiments.

in specific experiments fit perfectly Hopkins' algorithm. This happens in situations in which strategies *do* converge to an equilibrium price[48].

Nevertheless, agents more often fit just one side of the algorithm in the sense that a price hike that raised profits the previous period is followed by another price hike in the next period[49]. And this is especially true in experiment 4. I think that one explanation to this result is that, in experiment 4, the equilibrium price is far from the unit cost and, given that players are generally hesitant to charge 'high prices', they face situations in which a price decrease results in a profit increase less often than situations in which the opposite happens.

When players 'try' strategies that lie far from any of the two equilibria, either the Bertrand-Nash or the joint monopoly[50], their behaviour seems to be described by algorithms different from the one presented in Hopkins [1992]. The data reveal a kind of behaviour that can be generalized with: *"if a price hike (cut) raised (decreased) profits the previous period, a price hike (cut), of an arbitrary amount, follows"*. Such a behaviour can be described with the following algorithm:

$$p_{it} = p_{it-1} + \omega_t \cdot sign[\pi_{it-1} - \pi_{it-2}] + \epsilon_t \qquad \text{(I.8)}$$

where ϵ_t is distributed as a $N(0,1)$ and ω_t is a random variable distributed uniformly on (0,45). This is an algorithm that could seem unstable since the

[48]Experiments 2 and 5 define situations that converge towards the joint monopoly equilibrium price. Also, experiments 3 and 4 are characterised by clear convergence to the Bertrand-Nash equilibrium price.

[49]But which does not apply for a price cut.

[50]This is the case of experiment 1.

direction of changes in prices as well as their magnitude depend on the sign of previous profit changes. However, the results of the experiments show that prices always remain very close to both equilibria of the one-shot game[51].

To make a brief parenthesis, I considered the possibility that some players conditioned their decisions not only on their profits in past periods, but also on demand changes. Price decisions, however, do not seem to be conditioned on the trajectory of the demand. Nevertheless, I observed that some players reacted to a decrease (increase) in demand by decreasing (increasing) their price in the next period. When this happens, players react to decreases in demand by fixing a lower price in next period even if the profit had increased in the previous period. This, of course, cannot be considered as a general rule.

Rather than a tâtonnement process, I have observed that the choice of strategic variables at each period and the resulting profits allow agents to learn about the structure of the model and the strategies adopted by their adversaries. The existence of convergence to an equilibrium corroborates this conjecture.

Consider the calibrated iterated-choice algorithm developed by Arthur [1990] on human learning. At each time t, the agent associates a vector of strengths with the N possible actions to undertake. The strength vector

[51]A general analysis of the series of prices as times-series data indicated that, except for the white noise series mentioned, all series are stationary processes generated by either autoregressive models $AR(1)$ ($i.e. p_{it} = \delta + \Phi p_{i,t-1} + \epsilon_{it}$) or by autoregressive-moving average processes $ARMA(1,1)$ (i.e. $p_{it} = \delta + \Phi p_{i,t-1} - \psi \epsilon_{i,t-1} + \epsilon_{it}$). Two tests were applied to fit a generator model of each series, the t-statistic of significance and the Akaike's [1973] fit measure (AIC) that determines the appropriate lag length and which rewards good fit but penalises the loss of degrees of freedom. See Greene [1993] for details.

summarises the current confidence the agent has learned to associate with actions. The agent chooses his/her action with probabilities proportional to his/her current confidence in the N actions and learning takes place as these probabilities of actions are updated. Players in the experiments may have been thinking a similar way. Players may have been fixing specific intervals, setting their prices within those intervals with a specific probability. These intervals of prices as well as the probabilities could have been changing as time went on, making of this a way of learning.

I.7.3 Least Squares Learning Process

It is worth discussing the ordinary least squares process as a possible learning rule for the mis-specified model. Remember that the estimation of the demand function by ordinary least squares (OLS) was part of the information set of players in this series of experiments. The reason for including that as part of the information to be consulted has to be found in the importance that the OLS method has been given by the literature on learning.

Authors like Bray [1982] and Marcet and Sargent [1989] establish that convergence to rational expectations will occur with a 'reasonable' learning process such as ordinary least squares learning[52]. Working with least squares estimation, Kirman [1975, 1983] shows that a 'reasonable' learning process

[52]Marcet and Sargent work with an adaptive model in which functions change over time in a way designed to make them more consistent with the unknown laws of motion governing the environment. However, agents operate under the continually falsified assumption that the law of motion is time invariant and known for sure. The learning algorithm is represented recursively, in the form of a stochastic difference equation and the only possible limit points of that equation for the perceived law of motion are the rational expectations equilibria.

could make the sequence of prices converge to the Cournot-Nash solution, provided that the estimate of the slope demand equals the true slope of the demand[53]. By simulations, he arrives at the conclusion that,

> "... it becomes clear that the process does indeed converge given an arbitrary set of starting conditions. However, the problem of establishing convergence analytically remains unresolved. Evidently, there are special cases that can be disposed of quickly. Consider the case where there are two firms playing two periods. If each period both players fix the same price with respect to each other, the process converges to the collusive solution and firms act as a joint monopoly."

More recently, Brousseau and Kirman [1991] outlined the importance of testing whether agents use the least-squares method in order to get additional information about the market. The theoretical conclusion of Brousseau and Kirman [1991] is that least squares is not stable. They show that, in general, firms do not converge to the Nash equilibrium prices. Moreover, firms will not receive any indication that their initial model is mis-specified. With OLS, as the number of observations increases, each new observation has a decreasing effect on parameter estimates. Therefore, the trajectory of prices depends on initial conditions and slows as time passes. The conclusions of Brousseau and Kirman [1991] are confirmed by Hopkins' [1992] simulations.

The prices suggested by the OLS estimation of firm i's demand on its own price, are expressed by:

$$p_i = \frac{\hat{a}_i}{2\hat{b}_i} + \frac{c}{2} \tag{I.9}$$

[53]Kirman works with a symmetric quantity-setting duopoly model in which the firms are unaware that their demands depend on each other's actions.

where $\hat{a}_i$ and $\hat{b}_i$ are the estimates of the parameters of the following regression:

$$q_i = a_i - b_i p_i \tag{I.10}$$

Firstly and, in contrast with Chautard and Raby's [1991] experiments, players did not refuse to use the OLS method. Some of them applied the ordinary least squares method to estimate the demand function[54]. For example, player 2 in experiment 5 used OLS option most of the periods[55] and it is precisely this player who charges the Bertrand-Nash equilibrium price (112) in the last period. This player was observed to use the OLS option after period 5. This may explain that, after period 7, player 2 charged prices that are not far from what would be the best response if the model estimated by the OLS were the true model. This observation contradicts Brousseau and Kirman [1991]. However, my conclusion is that this can not be considered as resulting from the use by players of the OLS estimated model as the true one[56]. I analysed the evolution of the OLS estimates period by period. Every new observation adds no information to the estimated parameters of the demand function. In this sense, changes in the prices charged each period are not translated in changes in the prices suggested by the OLS estimation of the demand function.

[54]At the end of each one of the experiments, I collected the sheets of paper which I gave the players in the beginning of each experiment.

[55]At the end of the experiment, she said that she chose prices using the OLS's option of the menu.

[56]In fact, player 2 should have set prices around 114.

Most of the players were observing the OLS-help on the main menu but, looking at the past, they could realise that the actions taken by the other firms were affecting their own profits and that this effect was not captured by the simple model of the demand function estimated by OLS. These players indicated that they gave up using OLS before making their decisions.

As a result, players were just observers of the OLS help-facility and I am sure that this method helped them to learn how the demand function did not look like. The results concerning convergence have no direct relation with the OLS learning rule. In these experiments, the mis-specified part of the model seems to be too important and, therefore, a simple regression would never blind the firms.

Table C contains the OLS estimations obtained over all periods along the five experiments for each firm:

TABLE C

OLS Estimates						
	Parameter	**Firm 1**	**Firm 2**	**Firm 3**	**Firm 4**	**Firm 5**
	$\hat{a}_{1i}$	524	532.6	529	572	526
	$\hat{b}_{1i}$	2.6	2.7	2.7	3	2.6
Experiment 1	$S.d.(\hat{a}_{1i})$	5.35	2.23	5.6	9.3	2.56
	$S.d.(\hat{b}_{1i})$	0.08	0.02	0.08	0.12	0.03
	R_1^2	0.98	0.99	0.98	0.97	0.99
	$\hat{a}_{2i}$	530	551	458	524	534
	$\hat{b}_{2i}$	2.66	2.88	1.89	2.66	2.77
Experiment 2	$S.d.(\hat{a}_{2i})$	6.23	14.9	43.7	8.97	11.3
	$S.d.(\hat{b}_{2i})$	0.03	0.14	0.17	0.06	0.08
	R_2^2	0.99	0.95	0.86	0.98	0.98
	$\hat{a}_{3i}$	541	492	547	558	550
	$\hat{b}_{3i}$	2.79	2.39	2.8	2.9	2.85
Experiment 3	$S.d.(\hat{a}_{3i})$	4.56	6.9	3.32	5.4	5
	$S.d.(\hat{b}_{3i})$	0.1	0.07	0.05	0.16	0.12
	R_3^2	0.97	0.98	0.99	0.94	0.96
	$\hat{a}_{4i}$	584.6	694	661.9	650	649.9
	$\hat{b}_{4i}$	2.17	3	2.78	2.78	2.65
Experiment 4	$S.d.(\hat{a}_{4i})$	73.38	34	68	62	78.3
	$S.d.(\hat{b}_{4i})$	1.13	0	0.55	0.57	0.7
	R_4^2	0.16	0.99	0.57	0.57	0.44
	$\hat{a}_{5i}$	509.9	521.7	523.6	-	-
	$\hat{b}_{5i}$	2.6	2.77	2.7	-	-
Experiment 5	$S.d.(\hat{a}_{5i})$	13.19	5.9	7.78	-	-
	$S.d.(\hat{b}_{5i})$	0.18	0.04	0.06	-	-
	R_5^2	0.93	0.99	0.99	-	-

I.8 Conclusions

I have applied experimental methods to test learning behaviour in a market which is repeated a finite number of periods and in which firms have imperfect information about the specification of the demand. Firms produce a differentiated product, an aspect that has not yet been studied in an experimental setting. Without particularly restrictive assumptions, I have observed convergence around the Bertrand-Nash and the joint monopoly equilibrium prices. Nevertheless, the non-cooperative solution seems to attract players' strategies in the long-run.

In fact, when firms have imperfect information about demand and, therefore, about payoffs, prices are more likely to converge to the Bertrand-Nash equilibrium than to the joint monopoly equilibrium.

Quasi-convergence to the non-cooperative solution was observed when the objective was to maximise total accumulated profits. Nevertheless, an additional incentive to be among the 'best' firms in the industry does not seem to result in convergence to either of the two equilibria. A strong tendency to converge to the Bertrand-Nash equilibrium was observed in a model with higher strategic complementarity. Therefore, the degree of product differentiation plays an important role in determining the process of convergence.

On the contrary, but also under imperfect information about the structure of demand, convergence to the collusive solution is more likely to be observed when the number of firms decreases.

If there is perfect information about the true model, prices clearly converge to the one shot non-cooperative solution. Thus, and contrary to the results asserted by the literature on experiments in oligopoly, no evidence has been found for any collusive behaviour when firms have symmetric payoffs and

full information about payoffs and about opponents' choices. Not only is convergence to the non-cooperative prices observed, but prices start moving clearly towards the direction of the non-cooperative equilibrium half the way through the time horizon.

The results of the experiments presented here show that, in general, agents use simple mechanical rules to decide their strategies. They choose their strategies realising that their performance in the past has depended on their rivals' actions. The algorithm that can be used to simulate agents' responses does not explicitely involve any optimisation. The algorithm does not differ much from other human learning rules already analysed in the literature[57].

Although agents in the experiments do not seem to rely too much on statistics based on past actions, the ordinary least squares method appears to be a good reference for agents' decision making. In general, if players had taken the OLS estimated demand function as the true model when setting prices, the result advanced already by Brousseau and Kirman [1991] of not convergence to the Nash equilibrium price would not have been confirmed. All prices suggested by the OLS estimated demand, from the seventh period on, are close to the Bertrand-Nash solution. As a consequence, the 'human' algorithm actually used by agents, resulted in prices from the OLS estimated model converging to the non-cooperative equilibrium price.

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[57]All based on the Holland's *et al.* [1987] 'classifier system' in which classifiers are concatenated into an interdependent network, with actions taken serving as conditions for triggering choice among further, dependent actions. Note: a classifier is a condition/action couple where the action is allowed to be activated only if the condition is fulfilled.

I.9 Appendix: Instructions and Data Tables

I.9.1 Instructions

The intructions available to players at the beginning of each experiment are presented next. Note that bold characters are used to emphasize those points that are specific to one experiment or a subset of experiments, but not common in *all* of them.

Experiment 1

This is an experiment about decision making in an industry. The instructions are simple. Follow them carefully. The quantity of money that you will receive is going to depend on your decisions and on the decisions of the other players. You will receive a quantity of money in cash at the end of the experiment.

You are going to take part in the experiment that will start in the next few minutes. To be able to play, you have to use the following information:

1. There are five firms in the industry. You are one of them.

2. The unit cost of production is constant and equal to 40 monetary units.

3. You produce a product that is one of the differentiated varieties produced in this industry. All firms produce at the same unit cost.

4. Your decision variable is *price*. Each period you have to decide the price of your product and wait for the demand that corresponds to that specific price and the prices set by the rest of the players.

5. Each period has a duration of exactly 2.5 minutes. Therefore, you have two and a half minutes to decide the price for the next period.

6. The industry lives a total of **20 periods.**

7. If you do not fix any price, the price by default will be the price you

fixed the previous period.

8. At the end of each period, you will know through the screen the demand and the profit that correspond to the price fixed for that period.

9. If you fix a price that corresponds to a negative demand you will obtain a zero demand and profit respectively.

10. There are some additional help-facilities:

- graphics showing the evolution over time of profit-price and price-demand.
- the prices fixed by the other firms in the past.
- least squares estimation of the demand function based on your past observations.

11. The reward you will receive for your participation in this experiment consists of a quantity equal to your total profits over the 20 periods multiplied by an equivalence factor of 0.01 pesetas. Therefore, the more profits you make the more money you will earn.

Thank you for your collaboration. Are you ready?.

Note: Any comment will be welcome. Aurora García

Experiment 2

This is an experiment about decision making in an industry. The instructions are simple. Follow them carefully. The quantity of money that you will receive is going to depend on your decisions and on the decisions of the other players. You will receive a quantity of money in cash at the end of the experiment.

You are going to take part in the experiment that will start in the next few minutes. To be able to play, you have to use the following information:

1. There are **five** firms in the industry. You are one of them.

2. The unit cost of production is constant and equal to 40 monetary units.

3. You produce a product that is one of the differentiated varieties produced in this industry. All firms produce at the same unit cost.

4. Your decision variable is *price*. Each period you have to decide the price of your product and wait for the demand that corresponds to that specific price and the prices set by the rest of the players.

5. Each period has a duration of exactly 2.5 minutes. Therefore, you have two and a half minutes to decide the price for the next period.

6. The industry lives a total of **20 periods.**

7. If you do not fix any price, the price by default will be the price you fixed the previous period.

8. At the end of each period, you will know through the screen the demand and the profit that correspond to the price fixed for that period.

9. If you fix a price that corresponds to a negative demand you will obtain a zero demand and profit respectively.

10. There are some additional help-facilities:

- graphics showing the evolution over time of profit-price and price-demand.
- the prices fixed by the other firms in the past.
- least squares estimation of the demand function based on your past observations.

11. The reward you will receive for your participation in this experiment consists of a fixed quantity of 1000 pesetas plus an additional quantity equal to your total profits over the 20 periods, multiplied by an equivalence factor of 0.006 pesetas. Additionaly, a quantity of 1000 pesetas will be distributed, proportionally to their total profits, between the two players that will have the highest

accumulative profits in the 20 periods.

Thank you for your collaboration. Are you ready?.

Note: Any comment will be welcome. Aurora García.

Experiment 3

This is an experiment about decision making in an industry. The instructions are simple. Follow them carefully. The quantity of money that you will receive is going to depend on your decisions and on the decisions of the other players. You will receive a quantity of money in cash at the end of the experiment.

You are going to take part in the experiment that will start in the next few minutes. To be able to play, you have to use the following information:

1. There are **five** firms in the industry. You are one of them.

2. The unit cost of production is constant and equal to 40 monetary units.

3. You produce a product that is one of the differentiated varieties produced in this industry. All firms produce at the same unit cost.

4. Your decision variable is *price*. Each period you have to decide the price of your product and wait for the demand that corresponds to that specific price and the prices set by the rest of the players.

5. Imagine that you are firm i and j denotes any one of the other firms. The mechanism that determines your demand in the market is given by the following function:

$$q_i = \alpha - \beta p_i + \theta \sum_{j \neq i} p_j$$

where $\alpha = 500$, $\beta = 3$, $\theta = 0.14$.

6. Each period has a duration of exactly 2.5 minutes. Therefore, you have two and a half minutes to decide the price for the next period.

7. The industry lives a total of **20 periods.**

8. If you do not fix any price, the price by default will be the price you fixed the previous period.

9. At the end of each period, you will know through the screen the demand and the profit that correspond to the price fixed for that period.

10. If you fix a price that corresponds to a negative demand you will obtain a zero demand and profit respectively.

11. There are some additional help-facilities:

- graphics showing the evolution over time of profit-price and price-demand.
- the prices fixed by the other firms in the past.
- least squares estimation of the demand function based on your past observations.

12. The reward you will receive for your participation in this experiment consists of a quantity equal to your total profits over the 20 periods multiplied by an equivalence factor of 0.01 pesetas. Therefore, the more profits you make the more money you will earn.

Thank you for your collaboration. Are you ready?.

Note: Any comment will be welcome. Aurora García.

Experiment 4

See instructions for experiment 1. The difference between experiments 1 and 4 is that the value of parameter θ is different. However, this does not result in changes in the instructions.

Experiment 5

This is an experiment about decision making in an industry. The instructions are simple. Follow them carefully. The quantity of money that you will receive is going to depend on your decisions and on the decisions of the other players. You will receive a quantity of money in cash at the end of the experiment.

You are going to take part in the experiment that will start in the next few minutes. To be able to play, you have to use the following information:

1. There are **three** firms in the industry. You are one of them.

2. The unit cost of production is constant and equal to 40 monetary units.

3. You produce a product that is one of the differentiated varieties produced in this industry. All firms produce at the same unit cost.

4. Your decision variable is *price*. Each period you have to decide the price of your product and wait for the demand that corresponds to that specific price and the prices set by the rest of the players.

5. Each period has a duration of exactly 2.5 minutes. Therefore, you have two and a half minutes to decide the price for the next period.

6. If you do not fix any price, the price by default will be the price you fixed the previous period.

7. At the end of each period, you will know through the screen the demand and the profit that correspond to the price fixed for that period.

8. If you fix a price that corresponds to a negative demand you will obtain a zero demand and profit respectively.

9. There are some additional help-facilities:

- graphics showing the evolution over time of profit-price and price-demand.
- the prices fixed by the other firms in the past.
- least squares estimation of the demand function based on your past

observations.

10. The reward you will receive for your participation in this experiment consists of a quantity equal to your total profits over all periods multiplied by an equivalence factor of 0.01 pesetas. Therefore, the more profits you make the more money you will earn.

Thank you for your collaboration. Are you ready?.

Note: Any comment will be welcome. Aurora García

I.9.2 Data and Result Plots

Experiment 1

Data

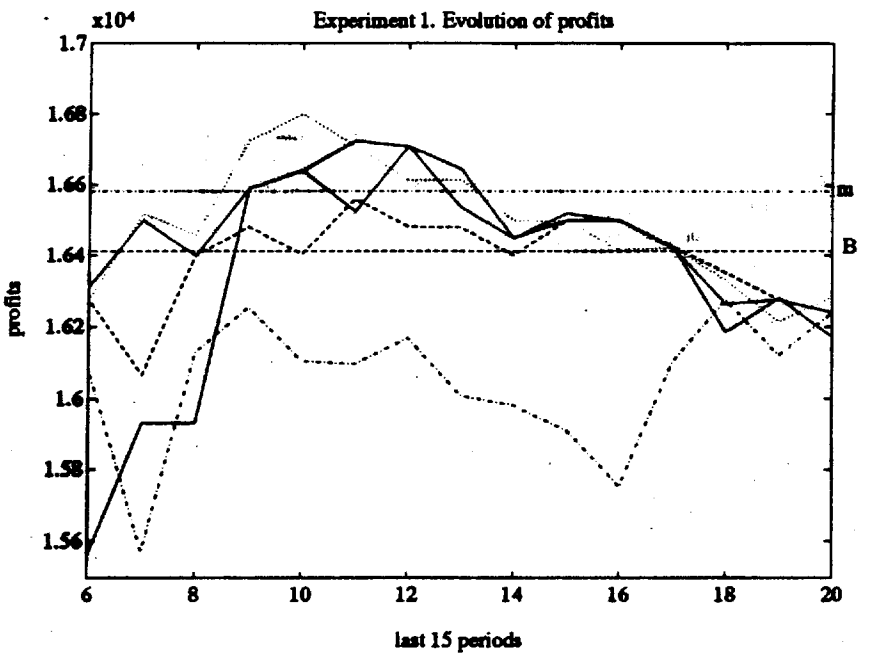
TABLE 1

EXPERIMENT 1															
Period	Firm 1			Firm 2			Firm 3			Firm 4			Firm 5		
	p_1	q_1	Π_1	p_2	q_2	Π_2	p_3	q_3	Π_3	p_4	q_4	Π_4	p_5	q_5	Π_5
1	60	366	7320	50	397	3970	55	381	5715	150	83	9130	70	334	10020
2	80	310	12400	60	373	7460	66	348	9744	160	59	7080	70	342	10260
3	105	229	14885	75	323	11305	98	251	14558	70	339	10170	70	339	10170
4	90	283	14150	85	299	13455	115	205	15375	100	252	15120	80	315	12600
5	100	250	15600	110	228	15960	117	206	15862	110	228	15960	90	291	14550
6	97	273	15561	115	217	16275	115	217	16275	120	201	16080	110	233	16310
7	99	270	15930	125	189	16065	110	236	16520	130	173	15570	115	220	16500
8	99	270	15930	120	205	16400	118	211	16458	124	192	16128	120	205	16400
9	119	210	16590	122	201	16482	115	223	16725	126	189	16254	119	210	16590
10	120	208	16640	125	193	16405	115	224	16800	128	183	16104	120	208	16640
11	115	223	16725	120	207	16560	117	217	16709	127	185	16095	121	204	16524
12	117	217	16709	122	201	16482	118	213	16614	126	188	16168	117	217	16709
13	116	219	16644	120	206	16480	111	234	16614	127	184	16008	118	212	16536
14	110	235	16450	117	213	16401	115	220	16500	125	188	15980	110	235	16450
15	115	220	16500	115	220	16500	113	226	16498	126	185	15910	110	236	16520
16	115	220	16500	115	220	16500	107	245	16415	126	179	15752	113	226	16498
17	109	238	16422	115	219	16425	109	238	16422	123	194	16102	115	219	16425
18	116	214	16264	113	224	16352	111	230	16330	115	217	16275	105	249	16185
19	115	217	16275	115	217	16275	107	242	16214	105	248	16120	114	220	16280
20	110	232	16240	110	232	16240	109	236	16284	110	232	16240	117	210	16170
$\sum_{i=1}^{20} \Pi_i^i$			309735			297992			308632			298246			304337

Evolution of Profits in a Plot

In the graph that corresponds to Figure 6, m denotes the joint monopoly equilibrium profit and B denotes the Bertrand-Nash equilibrium one.

Figure I.6: **Profits. Experiment 1**



Experiment 2

Data

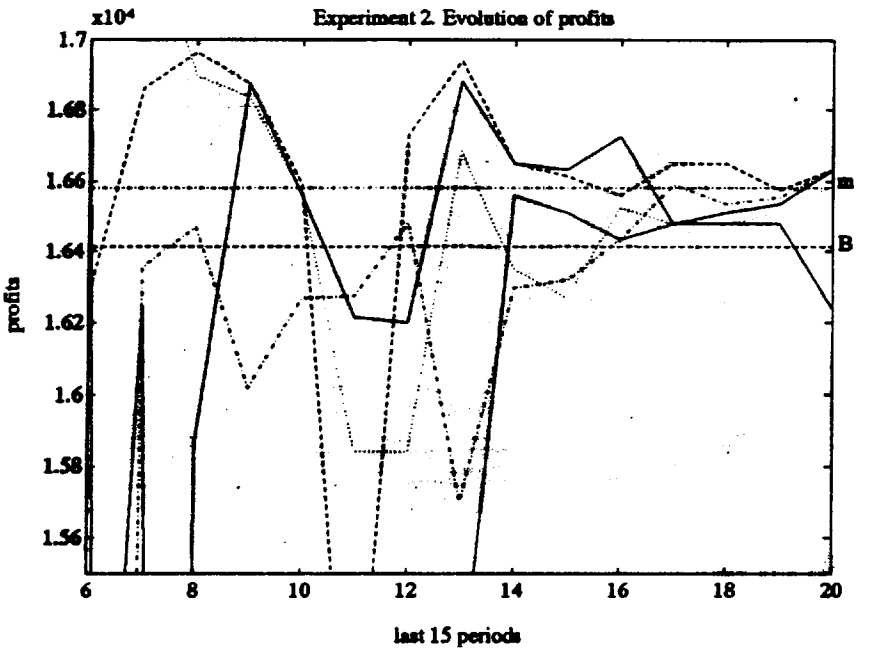
TABLE 2

EXPERIMENT 2															
Period	Firm 1			Firm 2			Firm 3			Firm 4			Firm 5		
	p_1	q_1	Π_1	p_2	q_2	Π_2	p_3	q_3	Π_3	p_4	q_4	Π_4	p_5	q_5	Π_5
1	50	388	3880	60	357	7140	100	231	13860	56	369	5904	55	372	5580
2	70	352	10560	49	418	3762	300	0	0	47	424	2968	45	430	2150
3	0	536	-21440	80	285	11400	5	520	-18200	70	316	9480	100	222	13320
4	80	300	12000	125	158	13430	0	551	-22040	84	287	12628	75	315	11025
5	85	312	14040	160	77	9240	80	328	13120	120	202	16160	120	202	16160
6	125	202	17170	95	296	16280	109	252	17388	195	0	0	150	123	13530
7	200	0	0	100	281	15860	107	259	17353	134	174	16356	135	171	16245
8	135	167	15865	105	261	16965	104	264	16896	130	183	16470	174	44	5896
9	115	225	16875	115	225	16875	109	244	16836	130	178	16020	145	131	13755
10	109	240	16560	110	237	16590	109	240	16560	123	196	16268	137	152	14744
11	109	235	16215	90	295	14750	100	264	15840	115	217	16275	141	135	13635
12	100	270	16200	110	239	16730	130	176	15840	122	201	16482	139	148	14652
13	120	211	16880	110	242	16940	123	201	16683	134	167	15698	138	154	15092
14	115	222	16650	115	222	16650	123	197	16351	124	194	16296	120	207	16560
15	112	231	16632	111	234	16614	123	196	16268	122	199	16318	119	209	16511
16	115	223	16725	120	207	16560	121	204	16524	123	198	16434	123	198	16434
17	120	206	16480	115	222	16650	120	206	16480	119	210	16590	120	206	16480
18	119	209	16511	115	222	16650	120	206	16480	118	212	16536	120	206	16480
19	118	212	16536	115	221	16575	119	209	16511	117	215	16555	120	206	16480
20	117	216	16632	117	216	16632	119	210	16590	117	216	16632	125	191	16235
$\sum_{t=1}^{20} \Pi_t$			250971			293293			235340			276070			270964

Evolution of Profits in a Plot

See next page.

Figure I.7: **Profits. Experiment 2**



Experiment 3

Data

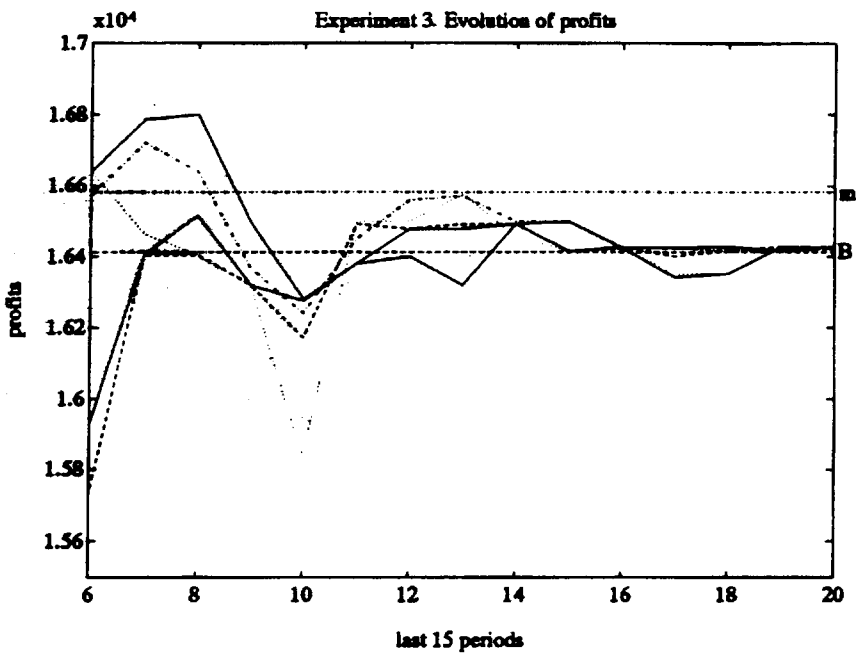
TABLE 3

EXPERIMENT 8															
Period	Firm 1			Firm 2			Firm 3			Firm 4			Firm 5		
	p_1	q_1	Π_1	p_2	q_2	Π_2	p_3	q_3	Π_3	p_4	q_4	Π_4	p_5	q_5	Π_5
1	150	110	12100	150	110	12100	100	267	16020	90	299	14950	90	299	14950
2	135	173	16435	210	0	0	125	204	17340	110	251	17570	110	251	17570
3	135	175	16625	130	191	17190	175	49	6615	125	206	17510	140	159	15900
4	133	169	15717	130	178	16020	130	178	16020	100	273	16380	125	194	16490
5	130	180	16200	130	180	16200	128	187	16456	120	212	16960	125	196	16660
6	130	177	15930	132	171	15732	120	208	16640	105	255	16575	120	208	16640
7	125	193	16405	125	193	16405	124	196	16464	120	209	16720	117	218	16786
8	123	199	16517	125	193	16405	125	193	16405	120	208	16640	115	224	16800
9	120	204	16320	120	204	16320	120	204	16320	106	248	16368	113	226	16498
10	115	217	16275	117	210	16170	100	264	15840	110	232	16240	114	220	16280
11	118	210	16380	116	217	16492	115	220	16500	110	235	16450	118	210	16380
12	117	214	16478	117	214	16478	115	220	16500	112	230	16560	120	205	16400
13	117	214	16478	116	217	16492	115	221	16575	113	227	16571	122	199	16318
14	116	217	16492	116	217	16492	118	211	16458	115	220	16500	116	217	16492
15	116	216	16416	116	216	16416	116	216	16416	113	226	16498	115	220	16500
16	115	219	16425	114	222	16428	114	222	16428	113	225	16425	113	219	16425
17	113	225	16425	111	231	16401	115	218	16350	113	225	16425	116	215	16340
18	114	222	16428	112	228	16416	115	218	16350	112	228	16416	115	218	16350
19	116	216	16416	114	222	16428	114	222	16428	112	228	16416	114	222	16428
20	114	222	16428	114	222	16428	114	222	16428	113	225	16425	113	225	16425
$\sum_{t=1}^{20} \Pi_t$			322890			307013			318553			330599			328632

Evolution of Profits in a Plot

See next page.

Figure I.8: **Profits. Experiment 3**



Experiment 4

Data

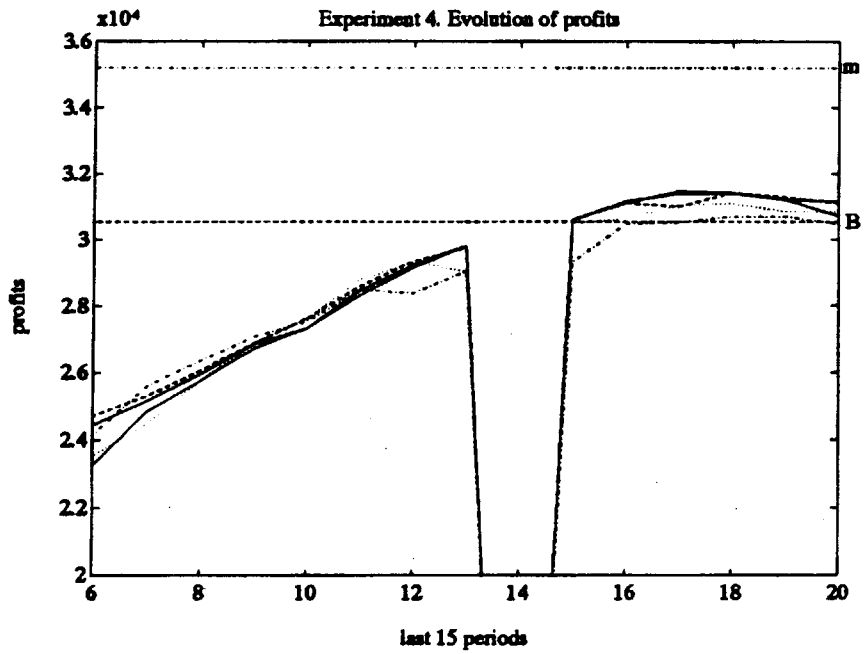
TABLE 4

EXPERIMENT 4															
Period	Firm 1			Firm 2			Firm 3			Firm 4			Firm 5		
	p_1	q_1	Π_1	p_2	q_2	Π_2	p_3	q_3	Π_3	p_4	q_4	Π_4	p_5	q_5	Π_5
1	99	374	22066	175	116	15660	45	558	2790	150	201	22110	58	514	9252
2	97	381	21717	175	116	15660	70	473	14190	120	303	24240	65	490	12250
3	109	365	25185	100	395	23700	105	378	24570	200	55	8800	74	484	16456
4	119	297	23463	100	362	21720	110	328	22960	80	430	17200	96	376	21056
5	108	346	23528	115	322	24150	107	349	23383	105	356	23140	98	380	22040
6	113	335	24455	117	321	24717	105	362	23530	110	345	24150	103	369	23247
7	114	340	25160	116	333	25308	108	360	24480	120	320	25600	111	350	24850
8	117	337	25949	118	334	26052	114	348	25752	125	310	26350	114	348	25752
9	119	340	26860	120	336	26880	120	336	26880	135	285	27075	117	347	26719
10	119	346	27334	125	325	27625	125	325	27625	138	281	27538	119	346	27334
11	123	343	28469	140	286	28600	130	320	28800	141	282	28482	120	354	28320
12	127	336	29232	130	326	29340	138	299	29302	150	258	28380	125	343	29155
13	129	335	29815	127	342	29754	150	264	29040	150	264	29040	129	335	29815
14	133	0	0	-3960	12603	-50412000	140	0	0	159	0	0	126	0	0
15	138	312	30576	130	340	30600	142	299	30498	155	255	29325	139	309	30591
16	138	318	31164	140	311	31100	149	281	30629	150	277	30470	141	308	31108
17	139	317	31383	148	287	30996	147	290	31030	153	270	30510	138	321	31488
18	144	302	31408	142	308	31416	148	288	31104	152	274	30688	142	308	31416
19	142	306	31212	140	313	31300	149	283	30847	150	279	30690	142	306	31212
20	147	287	30709	140	311	31100	146	291	30846	150	277	30470	135	328	31160
$\sum_{t=1}^{20} \Pi_t$			519685			-49906322			488256			494258			483191

Evolution of Profits in a Plot

See next page.

Figure I.9: **Profits. Experiment 4**



Experiment 5

Data

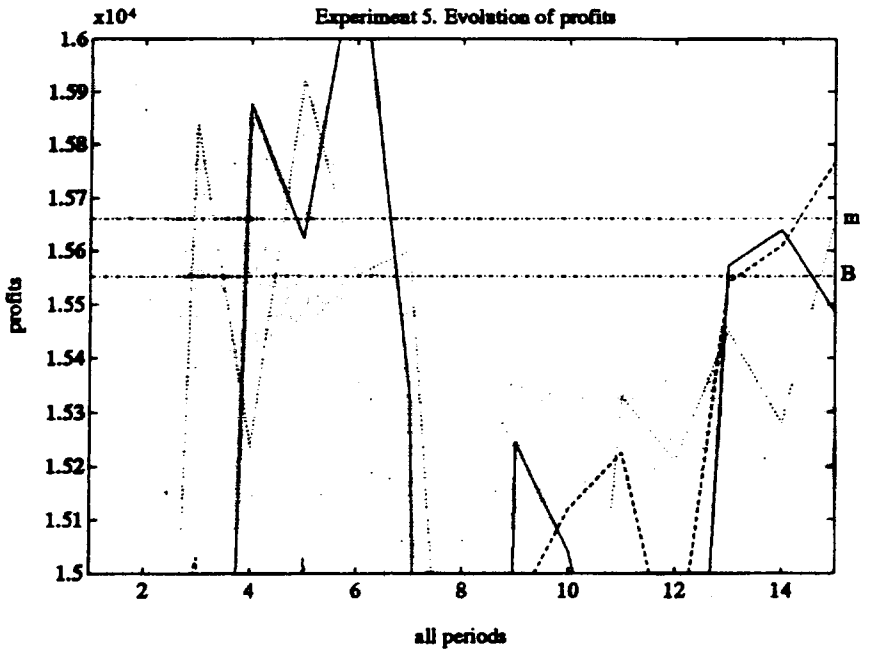
TABLE 5

EXPERIMENT 5									
Period	Firm 1			Firm 2			Firm 3		
	p_1	q_1	Π_1	p_2	q_2	Π_2	p_3	q_3	Π_3
1	79	263	10257	0	518	-20720	-1	521	-21361
2	99	246	14514	100	243	14580	85	291	13095
3	145	119	12495	130	167	15030	100	264	15840
4	124	189	15876	170	40	5200	92	293	15236
5	124	186	15624	130	167	15030	120	199	15920
6	114	219	16206	135	151	14345	125	183	15555
7	99	260	15340	130	160	14400	115	208	15600
8	69	342	9918	115	193	14475	95	258	14190
9	114	206	15244	119	189	14931	85	299	13455
10	104	235	15040	110	216	15120	92	274	14248
11	94	271	14634	115	203	15225	110	219	15330
12	88	289	13872	120	185	14800	105	234	15210
13	108	229	15572	110	222	15540	115	206	15450
14	108	230	15640	110	223	15610	120	191	15280
15	119	196	15484	112	219	15768	116	206	15656
$\sum_{t=1}^{15} \Pi_t$			215716			179334			188704

Evolution of Profits in a Plot

See next page.

Figure I.10: **Profits. Experiment 5**



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Part II

Dominance in the Tetra Pak Case: An Empirical Approach

II.1 Introduction

One of the recent cases in European Community competition law concerns Tetra Pak, one of the world leaders in the field of cartons for liquid food and the equipment and technology for filling these cartons. Economic analysis has been applied to defend both the Tetra Pak and the EC Commission positions. Most of the work produced on both sides is theoretical. I undertake here an empirical approach to the Tetra Pak case.

The decision of the Commission was based on information that seems to prove Tetra Pak's anti-competitive behaviour. This paper aims at testing this result using the same information as the EC Commission. In particular, I test the hypotheses that Tetra Pak has a dominant position in the non-aseptic sector and that this position is due to Tetra Pak's abusive practices with respect to its monopoly in the aseptic sector.

Section 2 is a brief introduction to the Tetra Pak case. Section 3 makes a detailed description of the carton industry as a whole. In section 4, I attempt an analysis of the concept of 'dominance' from an economic and from a legal point of view. Section 5 discusses the arguments that have been used to defend the two different positions, the one of the EC Commission as the accuser and that of Tetra Pak as the accused, in the light of the legal and/or economic literature on dominance. Section 6 contains the empirical analysis of the case and the main results. Finally, in section 7 I discuss the main conclusions.

II.2 The Tetra Pak Case

The Tetra Pak group makes cartons for packing both fresh - or *non-aseptic* - and *aseptic* liquids. It has also its own technology for the manufacturing of

machines for both fresh and aseptic liquids. In the sector of aseptics, Tetra has only one competitor, PKL, which uses a different technology[58].

Tetra has one main competitor in the production of cartons for non-aseptics liquids: Elopak. Elopak brought the case to the EC Commission. More specifically, Elopak accused Tetra Pak for having infringed articles 85 and 86 of the EC Treaty[59].

The Tetra Pak case has gone through two stages. In the first stage, "Tetra Pak I" [1988], the Commission found that Tetra Pak had infringed article 86 by preventing potential competitors from having access to a novel technique of filling cartons under aseptic conditions[60]. In 1981 the British National Research and Development Council (NRDC) assigned an exclusive license for the use of this technique to Novus Corp, a member of the Liquipak group[61]. In 1986 Tetra got hold of the exclusive license assigned to Liquipak[62].

Tetra's exclusive license benefited from the block exemption provided for in the Commission's regulation concerning patent licensing agreements. However, the Commission referred to the fact that this benefit can be withdrawn

[58]The aseptic packaging *Tetra Brik* is exclusively produced by Tetra Pak.

[59]See EC Commission Decision [1988], 'Tetra Pak I' L 272/27, and [1991] 'Tetra Pak II', L 72/1.

[60]This technique concerns the UHT treated or fully sterilized milk.

[61]The Liquipak group specialises in the development and manufacturing of filling equipment for liquid food products. In 1986 Tetra acquired *Liquipak International Inc.* (St. Paul, Minnesota, USA), *Liquipak International BV* (Netherlands) and *Pak Center Limited* (UK). Tetra did not acquire Novus Corp which in 1983, however, had assigned its licence to the companies that Tetra subsequently acquired.

[62]The British Technology Group (BTG), a public undertaking which had meanwhile taken over NRDC's activities, did not raise objections to that acquisition.

when the licensed products are not exposed to effective competition. As a result, Tetra agreed to abandon exclusivity and BTG undertook to start negotiations with both Tetra and Elopak to grant non-exclusive licenses[63].

In the second stage of the case, Elopak Italia (Milan) asked the Commission to investigate whether or not Tetra Pak Italia[64] and its associated companies were infringing article 86 of the Treaty[65]. In its Decision "Tetra Pak II " [1991], the EC Commission charged Tetra Pak with having taken advantage of its dominant position in the aseptic sector in machines and cartons to commit abuses in the related sector of non-aseptics. Tetra Pak's alleged abuse includes the use of restrictive contracts, discriminatory and predatory pricing of its cartons and liquid packaging machinery, and even an exclusive contract preventing competitors from advertising in an Italian milk trade journal.

In July 1991, the European Commission fined the company a record Ecu 75 million for abusing its dominant market position in Western Europe, claiming that Tetra Pak had pursued a deliberate policy aiming to eliminate actual or potential competitors. Tetra Pak has appealed to the European Court against the fine. The case is still under investigation.

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[63]See Gyselen [1990] for a more detailed discussion.

[64]With headquarters in Modena.

[65]In principle, Italy was the only country affected by the denounce from the beginning. However, the EC Commission considers the EEC as the geographic market and, therefore, the decision was extended to all Member States. See Weiss [1972], Elzinga *et al.* [1973][1978], Shrieves [1978], Uri *et al.* [1985] and Scheffman [1985] for discussion on the 'correct' definition of geographic markets.

II.3 Analysis of the Industry

This section is a summary of the history of the firms involved in the case as well as a description of the products, the technology, the demand and the distribution sides of the market.

II.3.1 The History of the Firms

Tetra Pak

The Tetra Pak company started in 1951 in Sweden[66] with a single product, the tetrahedron-shaped package, known as 'Tetra Pak Standard'[67]. The next step was the development of the original aseptic carton packaging system in 1962 which made use of the cold sterilisation method[68]. The company expanded spectacularly following the introduction in 1969 of the revolutionary Tetra brik aseptic packaging system[69].

Ruben Rausing, the founder of Tetra Pak, did not allow Tetra Pak to diversify away from the packaging of beverages and other liquid food. However, Tetra kept expanding outside Sweden. Between 1974 and 1980, Rausing's invention caught on big in Europe and Japan. During those years, Tetra Pak's sales grew by 30 per cent annually. In 1985 it had a worldwide turnover of around 2000 million Ecu, in 1987 of 2400 million Ecu and approximately of

[66]More precisely, in Lund.

[67]This product was developed by Ruben Rausing in the late 40s. Ruben was inspired by his wife while she was stuffing sausage casings.

[68]With hydrogen peroxide, invented in the late 50s. With this method, the milk could stay fresh in the carton for months at a time.

[69]This allowed liquids to be hermetically sealed in cartons.

3600 million Ecu in 1990. Tetra Pak's largest market is Europe (54 per cent of turnover), followed by Asia (26 per cent), North and South America (12 per cent) and Africa (5 per cent)[70]. Tetra Pak is already seriously involved in carton packaging in Eastern and Central European countries[71]. Moreover it is on its way to establishing a production system similar to that already set up in Western Europe[72].

In 1986 Tetra acquired three companies of the Liquipak Group, which specialised in the development and manufacture of filling equipment for liquid food products. At the beginning of 1991, Tetra Pak took over Alfa-Laval, a manufacturer of food, agricultural and industrial process equipment. Tetra Pak controls 90 to 95 per cent of the aseptic sector in the European Community.

The company is still wholly-owned by the Rausings[73]. This makes Tetra a family concern, for which reason there is no public information about the company.

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[70]Figures of 1989.

[71]Since 1990 the main growth areas lay outside Western Europe: Eastern Europe, Asia and the USA.

[72]This system comprises of sales offices, packaging material plants, machines assembly factories and service centers.

[73]Hans and Gad Rausing, the two sons of Ruben Rausing.

Elopak

Elopak is a Norwegian group of companies created in 1957[74]. It is the main competitor of Tetra Pak in the outfiting[75] of cartons for use in packaging and distribution for fresh liquid food. Its activities have not yet been extended to the aseptic sector[76].

In 1987 Elopak acquired Purepak, the packaging-machine division of Excello (USA)[77]. Elopak is primarily engaged in Europe but also in Africa and the Middle East. In 1985 Elopak controlled the 27 per cent of the non-aseptic sector[78]. In 1987, it had a worldwide turnover of around 300 million Ecu[79].

Other Firms

The only competitor of Tetra in the aseptic sector is PKL which is controlled by a Swiss company[80]. PKL's market share is approximately 5 to 10 per cent of the sector. PKL produces also in the non-aseptic sector, in which it holds approximately 11 per cent of the market.

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[74]Its subsidiary in Milan (Italy) was established in 1969.

[75]It supplies and installs systems for filling, packaging and handling the cartons. However, Elopak did not manufacture the filling machines until the 80s. It just acted as a distributor for certain filling-machine manufacturers (Liquipak among others).

[76]Before the Tetra Pak's acquisition of Liquipak, Elopak had entered into a distribution agreement with Liquipak for machines capable of aseptically filling UHT treated milk. See 'Tetra Pak I', p. 272/31 for more details.

[77]Purepak has been trying to develop aseptic packaging machines.

[78]I assume this is an average percentage over all Member States of the Community.

[79]These are figures from the 'Tetra Pak I' and 'Tetra Pak II' EC decisions.

[80]PKL produces cartons and machines in both aseptic and non-aseptic sectors.

The rest of the non-aseptic sector is shared by small firms. In the production of carton packaging there are three firms, *Shouw Packing* (Denmark) which controlls 7 per cent, *Mono-Emballage/Scalpak* (France/Netherlands) which has 2.5 per cent of the sector and *Van Mierlo* (Belgium) with 0.5 per cent [81]. In the production of non-aseptic machines, approximately ten small firms share 13 per cent of the market left by Tetra, Elopak and PKL [82]. Tetra, Elopak and PKL are occasional distributors of these small firms.

II.3.2 Products and Relevant Market

Different definitions of the relevant market have been used concerning the Tetra Pak case. On one hand, in Tetra Pak I and II, the Commission distinguished four markets: the aseptic cartons, the supply of machines used for filling aseptic cartons, non-aseptic cartons, and the machines that fill them. On the other hand, Tetra claimed that the market is defined as the market of packaging, including carton, glass, plastic, etc.

The correct definition of relevant market is one of the major problems when analysing the activity of a specific industry and especially when deciding whether a firm behaves competitively or not. Among the factors that are considered in the literature on antitrust practices to be a good basis for determining a market we can find price sensitivity measured in terms of

[81] These three firms produce their own carton package and their market is concentrated in just one or two countries. They do not produce machines but they occasionaly distribute them.

[82] Mainly Nimco (USA) with 4%, Cherry Burrel (USA) with 2.5% and Shikoku (Japan) with 0.5%.

cross-elasticity of demand[83], cross-elasticity of supply [84], movements in relative price and quantities, and clustering[85]. In terms of competition policy, it has been said that no one method will always work and that, in certain settings, it may be true that no method would yield unambiguous results[86]. Each specific case may require a specific way of looking at the relevant market[87].

The activity of Tetra Pak includes two main sectors, the aseptic[88] and the non-aseptic[89]. Non-aseptically packaged products cannot be stored for a long time so that they need a very rapid and regular distribution system and there is always the risk of waste. The aseptic package gives to the product a 'shelf life' of several months.

Under this definition, there are varieties of an 'aseptic product' and varieties of a 'non-aseptic product'. Different varieties in the same sector are close substitutes. These two sectors define the number of products as well as of relevant markets. As far as the machines are concerned, they are part of the technology necessary for the production of the different packaging modes

[83]In the sense that products are in the same market if cross-elasticity is sufficiently high so that the price of a commodity tends to uniformity, allowance being made for transportation costs. See Steiner [1968].

[84]With the meaning that two producers can be regarded as competitors even though they may be currently producing products which are not competitive from the point of view of consumers. See Glassman [1980].

[85]If the firm involved is a multiproduct firm. See Schaerr [1985].

[86]See Glassman [1980].

[87]See also Steiner [1968].

[88]Free from infection.

[89]Used for packaging of fresh products.

and therefore[90], they should be treated as an input of the packaging production process. In the Tetra Pak case, I distinguish a market for two different varieties which belong, respectively, to two different sectors, the aseptic and the non-aseptic sectors.

In addition, the two sectors are related. On one hand, there is a demand relation between them since varieties of both sectors may be substitutes[91]. On the other hand, I would expect that a production relation exists between aseptics and non-aseptics. The Commission does not explicitly refer to any effect of the co-existence of the two types of products in the production line of the same firm. Nevertheless, it is plausible to assume that a producer of both aseptic and non-aseptic products experiences some savings in the fixed costs of production or that the production of one type of products affects unit production costs of the other type (e.g. in the case of economies of scale in the use of one input which is common to the production of both products[92]).

Aseptic Sector

The product of Tetra is a board tube head sealed at intervals through the liquid it contains and formed into a brik-shaped pack with no headspace. The entire process is continuous and takes place in a single machine that shapes

[90]Since they are products that are in a stage prior to the process of production and normally not destinated to be sold.

[91]For example, if I want to buy fresh milk but, at the moment of the purchase I consider the price too high, or I find out that there is only UHT milk left, I am likely to consider buying UHT milk instead.

[92]See Baumol *et al.* [1982].

and fills the package. Tetra produces two varieties of aseptic carton package[93]:

- Tetra Brik Aseptic, introduced in 1969/70, uses a six layer laminate[94]. The cartons are supplied in continuous rolls. The carton is formed and sealed on all sides at the same time as it is filled. Tetra brik aseptic cartons account for over 70 per cent of all Tetra Pak containers.

- Tetra Top, introduced recently, is reclosable and is available in round and square versions[95].

PKL is the only competitor of Tetra Pak in this sector. It produces the PKL brik, named Combibloc[96]. PKL produces also the machines for filling these cartons.

The aseptic package of carton, in different sizes, is used for juices, wine, flavoured beverages, dairy drinks and other liquid food[97].

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[93]Tetra Pak produces its own machines for filling these cartons. Tetra also produces equipment to facilitate the handling and storage of filled packages.

[94]The laminate consists of an outside polyethylene coating, printing ink, paper, a laminated polyethylene layer, aluminium foil and two internal polyethylene coating layers, or 75% paper, 20% polyethylene and 5% aluminium foil by weight.

[95]The package of 1 lt. is the only aseptic version of Tetra Top.

[96]This carton is supplied as an individual flattened preformed blank only requiring sealing after filling.

[97]Nearly the 90% of the cartons produced are used for milk or milk-based products. UHT and sterilized milk are aseptically packed. See EC Commission decision [1988] 'Tetra Pak I' for details.

Non-Aseptic Sector

Tetra Pak produces five different non-aseptic carton packages[98]:

- Tetra Classic (or 'Standard'), introduced in 1952 and formed from a roll of polyethylene coated board, wound into a tube during the filling process and then sealed through the liquid contents, so that no air is trapped inside.

- Tetra Brik, rectangular, based on the same principle used in the Tetra Classic[99].

- Tetra Rex, introduced in 1965, is a more traditional package with a pointed or flat top, used for pasteurised or fresh products.

- Tetra King dates back to 1981. It is based on an expanded polystyrene laminate and it features a reclosable pull-tab or a lid. It is used mainly for specialised dairy products.

- Tetra Top in its non-aseptical version.

Elopak produces the carton package Pure Pak which competes directly with the Tetra Rex[100].

PKL competes in the non-aseptic sector with its packages Quadrobloc and Pergabloc. It produces the machines associated with them.

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[98]Tetra produces also the machinery that goes with them. However, about 90% of the turnover in 1990 was in packages while 10% was in packaging machines.

[99]It was first launched in 1963.

[100]Elopak started its production of machines when it acquired Purepak. Before that, it has been a distributor, while producing some material for machine maintenance.

II.3.3 Technological Background

The technology which was the object of the license[101] assigned to Tetra in 1986 is based on the synergy of ultra violet light (UVL) and hydrogen peroxide[102]. With the basic sterilization process as a first requisite, much development on both the filling machine and carton were still necessary. In fact, the only technically acceptable aseptic carton packaging machines commercially available in the EEC for long shelf life treated liquid food[103] are the Tetra and PKL machines, both based on similar sterilization methods[104]. This method of sterilization[105] used by Tetra Pak and PKL is considered by Elopak as adequate for cartons supplied in continuous rolls (such as the Tetra brik) but it is less suited to gable-top cartons[106] such as those in which Elopak has experience[107]. Then, the 'non-entry' of Elopak in the production of aseptics

[101]See EC Commission decision [1988], 'Tetra Pak I'.

[102]UVL enhances greatly the sterilizing properties of the hydrogen peroxide.

[103]Especially the UHT treated milk. In fact some packaging machines for UHT liquids being developed or currently available are not suitable for milk but may be adequate for fruit juices.

[104]The other machines capable of packing aseptically UHT milk are either not available in the EEC and/or are no more than prototypes not effectively commercially exploited.

[105]Which is not patented.

[106]These cartons are lined with polyethylene and can be easily opened. They are used especially for the pasteurized or fresh milk. Machines developed to seal gable-top cartons cannot normally seal brik cartons. Even for a gable-top machine or a brik machine, the cartons must be adapted to fit the particular machine.

[107]The key for entering the market for supplying cartons for long shelf life food products lies in the ability to supply aseptic packaging machines for these cartons. A machine

may result from Elopak's inflexible technology[108].

Nearly 90 per cent of cartons, whether for aseptic or for fresh liquids, are used for milk or milk-based products. Milk in cartons is normally sold in one of two ways, either pasteurized (fresh) or aseptic (UHT-treated and sterilized milk). Cartons in both cases, aseptic and non-aseptic packaging, are made from paper-based boards of different weights and thicknesses depending on the specification required.

In the multi-layer liquid aseptic cartons[109], the polyethylene layer is the only material directly in contact with the product packaged. The board makes the packaging strong, the plastic renders it hermetic and the aluminium protects the product from light and oxygen and enables the packaging to be dealt by induction from outside.

Tetra has patented not only the technology concerning machines and carton packaging but also all the posterior modifications to those products[110]. Tetra holds more than hundred patents concerning the cartons and also more than hundred patents for the machines.

Due to technological reasons, entry into the aseptic packaging sector is difficult for a non-aseptic packaging producer. However, it is relatively easy

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producer must not only have an adequate sterilization technique for the cartons, but must also be able to incorporate this technique into a reliable filling machine capable not only of working continuously and reliably at high speeds but also of maintaining an aseptic-sterile environment in dairy conditions. These are the technical barriers to entry for production of machines.

[108]See Röller and Tombak [1990].

[109]Produced by Tetra Pak.

[110]As, for example, the way of plaiting the carton.

for a producer in the aseptic sector to enter the non-aseptic packaging for fresh liquid food.

II.3.4 Demand and Distribution Processes

Within the European Community, Tetra Pak has an assembly plant in Italy. It has production plants in Germany, France, United Kingdom, Italy, Netherlands, Portugal and Spain. Tetra Pak has never granted licenses for the production of its machines[111].

In the Community, firms of the Tetra Pak group distribute carton packages and machines directly to the milk firms, dairies and supermarkets. No independent distributor, except the distributors of Liquipak, distribute Tetra's products so that not much inter-brand competition is possible.

The machines produced by Tetra Pak are either rented or sold to its customers, and serviced through its own service centers. Tetra makes *lease contracts* for machines in five countries (Greece, Ireland, Italy, Spain and the United Kingdom) and *sales contracts* in all State Members except Greece and Spain[112].

The different types of packages and the different milks with which they are generally associated[113] have different characteristics, which lead consumers to regard them as imperfect substitutes. Each type of milk has different taste

[111]For the production of packages, Tetra has granted some licenses to several non EEC countries.

[112]See EC Commission decision [1991], 'Tetra Pak II', for details on the clauses of these contracts.

[113]Glass bottles, plastic bottles, plastic bags and gable-top cartons for fresh milk. Brik cartons for UHT milk. Plastic bottles, metal cans and glass bottles for sterilized milk.

and preservation qualities. Fresh milk is normally more expensive because it cannot be stored. Preserved milks (UHT and sterilized) can be produced during the seasons in which milk is cheaper and available in greater quantities for consumption when fresh milk is more expensive. Sterilized milk can be stored longer than UHT milk but is generally regarded as having an inferior taste. For historical and national reasons, differences in habits, tastes and preferences, structural trends in the demand for the various types of packages may be different in different Member States[114].

II.4 The issue of 'Dominance'

Following Article 86 of the 1957 Treaty of Rome 'any abuse by one or more undertakings of a dominant position within the Common Market or in a substantial part of it shall be prohibited as incompatible with the Common Market in so far as it may affect trade between Member States'[115].

In a 1965 memorandum, the Commission asserted that dominance is 'primarily a matter of economic potency, or the ability to exert on the operation of the market an influence that is substantial...'. In other words, dominance can only be proved by the existence of abusive conduct and where the latter is absent so is dominance[116].

[114]In France, only one third of the milk consumed is fresh compared with two-thirds in the Community as a whole. In Germany, about 60% of milk is fresh. In Italy, glass bottles for fresh milk are virtually unknown because the distribution infrastructure does not exist.

[115]Therefore, under this Regulation, the EEC does not prohibit the creation or strengthening of a dominant position, but only its abuse.

[116]The Court's judgements in the cases *United Brands* [1978] and *Hoffman-La Roche* [1979] made clear that their extremely large market shares (80 per cent in the Hoffman-La

Dominance has also been said to exist once a market share of the order of 40-50 per cent is reached, but this does not automatically give control so that other factors must be taken into account[117].

Different Member States have placed different emphasis on the criteria to be used to establish the existence of a dominant position. One main instrument of *German* competition policy[118] is the control of the market behaviour of market-dominating enterprises. Since 1973, the law defines a market-dominating enterprise as one which has no competitors[119], one which is not exposed to any substantial competition or one which has a paramount market position in relation to its competitors. A paramount market position can be identified for a dominant single firm which has a market share of

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Roche case) constitute evidence of dominance. However, at times, the Court seems to have had some difficulty in setting aside its misgivings about a dominant firm's conduct. Example of the last are ambiguous statements such as 'a finding that an undertaking has a dominant position is not in itself a recrimination but simply means that the undertaking concerned has a special responsibility not to allow its conduct to impair genuine undistorted competition on the common markets'. See Gyselen [1990] for details.

[117]For example, the degree of vertical integration, the control over the distribution process, the number of competitors, the degree of potential competition, the market share of firms ranked immediately below the leader, advertising expenditure, leadership in technical knowledge and success in defending market shares. See George and Jacquemin [1990].

[118]German Law Against Restraints of Competition, 1957.

[119]This does not seem to me a good definition of dominant firm since what differentiates a dominant firm from a monopolist is the fact that the dominant firm faces a fringe of small competitors. See Martin [1990].

one-third or more[120], and for dominant oligopolies a market share of one-half or more for the biggest three firms or a share of two-thirds or more for the biggest five firms[121].

The monopoly legislation[122] in the *UK*, says that a market may be liable to investigation when two or more companies together have a market share of at least 25 per cent and acts in a way that prevents, restricts or distorts competition.

Competition authorities in *France*[123] examine the importance of market share both in absolute terms and relatively to the market share of the competitors of a firm. However, a large market share is considered in itself insufficient to establish a dominant position[124].

In view of the legal meaning of dominance, it seems that, although a large market share is not a proof of dominance, it has been used in practice as the

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[120]The American jurisdiction of Section 2 of the Sherman Act does not cover firms with less than 60%. See Kantzenbach [1990].

[121]Most of the big companies would fall under this definition. To my opinion, this is too narrow a definition of a dominant firm that clearly is against the existence of oligopolies.

[122]Governed by the Fair Trading Act 1973 and the Competition Act 1980.

[123]Ordonnance No. 86-1243 du ier decembre, 1986 relative à la liberté des prix et de la concurrence.

[124]In addition to market share, competition authorities also take into consideration factors which may affect the possibility for competitors to develop their market shares or for potential entrants to actually enter the market considered: upward or downward vertical integration of the firm under investigation, superior management, technical superiority or product and image differentiation. They also take into account whether or not the firm under investigation belongs to a large financial group or holds monopoly power on unrelated markets. See Jenny [1990].

most[125] important measure of market power when assessing a firm's position in the market.

The best known economic conceptualization of a *'dominant firm'* is in terms of a particular sort of price leadership[126]. Although not satisfactorily considered in the economic literature, Scherer [1980] defines dominance in terms of relative firm size[127] which is just one of many possible consequences of a dominant firm[128].

Other possible definitions of dominance introduce the concept of *'differential movement advantage'* (DMA)[129]. In this sense, a dominant firm is a firm which has access to a DMA that can be exploited by making some credible commitment which pre-empts rivals, and thus restricts the scope of their actions[130]. However, the fact that a dominant firm can keep entrants out does not mean that it will choose to do so. A dominant firm will pursue the strategy that yields the largest profit. If it will reap a greater profit by letting a rival into the market than by deeping it out, it will prefer to let the rival

[125]If not the only one.

[126]According to Geroski and Jacquemin [1984], this is an unprofitable distinction evaded by the apparent follower and assumed perforce by the apparent leader. See also Scherer [1980].

[127]He uses 'roughly 40% or more of its industry output' as a criterion to define a dominant firm.

[128]See Geroski and Jacquemin [1984].

[129]The ability of a firm to precommit itself to a strategic position which narrows the range of replies open to its rival. See Geroski and Jacquemin [1984].

[130]This definition is compatible with the one that defines a dominant firm in terms of some 'specific advantage', for example, the control of a natural resource base, a distribution network, a patent, etc.

in[131].

In a second stage of dominance, there are tactics a dominant firm can employ to influence fringe firms' costs and beliefs about the way the dominant firm will react to fringe behaviour. In this way, once a firm achieves a dominant position[132], it can employ strategic behaviour to maintain that position[133]. For example, it may raise rivals' costs, invest in excess capacity, integrate vertically, differentiate its production through research and development or offer exclusive dealing contracts to consumers[134].

Tetra Pak qualifies as a dominant firm under some of these definitions, but only in the aseptic sector. Tetra's 1985 market share in the aseptic sector was more than 50 per cent in all Member States[135]. In addition to this large market share, Tetra Pak almost totally controls the distribution process of its products and, what is even more important, is a leader in the technical knowledge of machines for filling aseptic cartons. Under the definition of dominance given by George and Jacquemin [1990], Tetra Pak is a dominant firm in the aseptic sector of packaging for liquid food.

With respect to the non-aseptic sector, the only conclusion one can reach

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[131]See Martin [1990].

[132]Firms may achieve a dominant position by superior competitive performance, by merger, or by strategic behaviour designed to exclude competitors and prevent competition on the merits.

[133]This, however, goes beyond my analysis here.

[134]See Martin [1990] and Geroski and Jacquemin [1984] for an extensive analysis on the sustainability of dominance.

[135]This is true for machines and for cartons, with the only exception of Ireland in the case of cartons.

is that Tetra's position in the non-aseptic sector does not fall into any of the given definitions of dominance[136] and, therefore, it would be incorrect to talk about an abuse of dominance in that sector. It seems correct to look for a better explanation of what the position of Tetra is in the non-aseptic sector, and elaborate empiricaly this aspect of the case[137].

II.5 Debating "Tetra Pak II"

Section 2 was mainly an introduction to the procedural characteristics of the *Tetra Pak* case. This section follows the evolution of the case after the publication of the 'Tetra Pak II' decision in July 1991. More specifically, it describes the steps taken by Tetra Pak and the European Commission in order to defend their positions[138]. In particular, and due to the complexity of the case, I focus on the arguments that relate to dominance, the problem that constitutes the main interest of this part.

After a juridical evaluation of the case, the Commission decided that[139]:

> "... one should remember that the Court of Justice has considered as evidence of a dominant position market shares that are lower than the ones considered here. Moreover, in some Member States, Tetra Pak's market shares in the non-aseptic sector are such that there is, with no doubt, a dominant position even in the case that a different approach would consider these markets

[136]Except in the German definition.

[137]See Section 6.

[138]Three consultants have been analysing the case since, Professor Manfred Neumann, in the part of the Commission, and Professor Christian von Weizsäcker and Dr. Derek Morris, in the part of Tetra Pak.

[139]'Tetra Pak II' [1991], p. 72/21.

separately."

Tetra Pak's main disagreement with the Commission[140] is based on a different market definition adopted by Tetra Pak. Tetra defines the relevant market as the set of packaging modes – carton, glass bottles, plastic, etc. – for liquid food[141]. In this market, Tetra supplies aseptic and non-aseptic packaging integrated systems[142]. Furthermore:

> "... the relevant market can not longer be defined only in terms of cross price elasticity. The Commission's formula is inappropriate because it neglects competitive parameters other than price[143]."
>
> "... since it is true that long-term competitive pressure accomplishes beneficial results for customers then it does not make sense to exclude long-term substitution possibilities from the relevant market of a given product. Otherwise the relevant market does not capture the competitive pressures and opportunities".

This feature of the Tetra Pak case is similar to the analysis of the *'Cellophane case'*[144] in which the firm duPont was accussed of having monopoly

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[140]Remember that the Commission identifies four relevant markets, for machines and for cartons in the aseptic and non-aseptic fields respectively. The disagreement between the Commission and Tetra Pak concerning market definition and dominance derives from differences between short-term and long-term substitutability. The reason for the Commission to consider four relevant markets is that all different modes of packaging compete with each other only in the long term. In the short term, the demand and supply conditions are such that the elasticity of substitution of all these packages is 'almost' nule. See 'Tetra Pak II', p. 72/18.

[141]Under this definition of the market, Tetra Pak has a market share of 14%.

[142]Carton packaging machinery and the cartons in which various food products are packed.

[143]von Weizsäcker [1989].

[144]United States v. E.I. du Pont de Nemours and Co., 351 U.S. 377 (1956).

power in cellophane. In this case, the court defined the market for cellophane to be the relevant market. However, the trial court determined that the relevant market consisted of all 'flexible wrapping materials', meaning that duPont had a relatively low market share[145].

Tetra Pak introduces[146] the *'correct'* and *'realistic'* idea of competition. The structural changes[147] experienced by the European Economic Community in the last three decades could imply that the criterion followed in measuring the degree of competition in the market should also change. Tetra Pak concludes:

> "The Commission is in error to consider Tetra Pak to be dominant in a market for aseptic cartons. As long as new fields of application for aseptic carton exist, there is no doubt that Tetra is under competitive pressure which corresponds to the average in the Community economy."

Furthermore, Tetra observes that[148]:

> "There is no justification for the Commission including fruit juice and other liquid food in a relevant market defined in terms of aseptic carton packaging. Those products can be packed equally well non-aseptically and/or in containers other than cartons and the distinction between long-life and short-life for

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[145]This case was analysed following criteria of cross-elasticity of demand: "Given that a slight decrease in the price of cellophane causes a considerable number of consumers of other flexible wrappings to switch to cellophane, it is an indication that a high cross-elasticity of demand exists between them, that the products compete in the same market".

[146]von Weizsäcker [1989].

[147]Such as the shift occurred from the manufacturing sector to the service sector, the shift of employment from the activity of production to other activities like research and development, sales and marketing, etc, that contribute to increases in costs, an increasing degree of customer choice, are some of the mentioned factors that have caused those structural changes.

[148]von Weizsäcker and Morris [1991].

> these products is much less clear cut in terms of both production methods and in the eyes of consumers. Consequently, at least for non-milk products, the evident substitutability between aseptic and non-aseptic packaging makes any definitions that place these in different relevant markets inappropriate for assessing competitive pressures or market power".

According to Tetra Pak, as far as the sector of non-aseptic carton packaging is concerned, there are widespread and substantial longer-term substitution possibilities facing carton packaging suppliers, including glass bottles and plastic bottles. They assert that this assures not only the existence of high competitive pressure in the non-aseptic sector but also the existence of competitive prices.

In 'Tetra Pak II', the Commission clearly reiterates the idea that aseptic and non-aseptic cartons form distinct relevant markets. However, the decision goes on to argue that, though distinct, these two markets are 'related'[149]. It goes on to assert that, as a result, *abuses can and have occurred on the non-aseptic market by virtue of dominance on the aseptic sector,* that this conclusion is legally and economically justified and that, *as a result, Tetra Pak is dominant in the non-aseptic sector.* This seems to constitute a new definition of a dominant firm. Under this definition, a firm is dominant with respect to a market y if it is considered to be dominant, in the view of the past legal experience, in a different market x that is 'related' to market y. This is a rather rough concept in itself, especially because it is of a tautological nature. I am convinced that the case needs more attention. The Commission should apply a theoretical model which is appropriately designed to describe the main features of the Tetra Pak case with particular emphasis on the degree

[149]The Commission does not specify the meaning of this 'relation'.

of substitutability between aseptic and non-aseptic products.

II.6 Empirical Evidence

I use the data available from the Tetra Pak case to test the decision taken by the EC Commission concerning the relation between the aseptic and non-aseptic sectors. I also test how this relation can determine the position of the competing firms in each sector.

Since the decision affects all European countries, I use cross-section data which are available on the Tetra Pak case which refer to the EC Member States for the year 1985. This implies a total of 12 observations for each variable.

Figure 11 shows the relation between Tetra Pak's market shares in the two different sectors[150]. The correlation between Tetra Pak's market share in the aseptic sector and that in the non-aseptic sector, using data of 1985 for all countries that constitute the geographical market, is[151] $\rho_{a,na} = 0.2$. When the Commission expresses its opinion saying that [152]:

> "It will also be noticed that the rank order of market shares for cartons in the aseptic and the non-aseptic sectors are *closely* associated"[153].

it is implicitly refering to a positive correlation between market shares in the

[150]See Appendix 1.

[151]This correlation rises to 0.65 in the case of Italy over the time period 1977-1986.

[152]Neumann [1992].

[153]As a matter of fact, the market share for cartons in the aseptic sector for Ireland is below the 50 per cent. What Neumann says regarding this observation is that *'this low figure may be due to incomplete information'*. To my opinion, this argument cannot be valid since, as the EC Commission Decision, it is based on the available data.

two sectors. The correlation between the market share of Tetra Pak in the two sectors, although low, is in fact positive, which can be considered to confirm the Commission's claim. Since aseptic and non-aseptic products are defined to be demand substitutes, this relation would be expected to be negative[154]. If only demand relations exist between the aseptic and the non-aseptic sectors, a positive relation might be a result of Tetra Pak's anti-competitive behaviour, although this fact alone would not be sufficient to prove it.

As a first approach to an empirical analysis of the Tetra Pak case, I propose a regression analysis using the same data as the Commission. Following the EC Commission's criteria, Tetra's position in the aseptic sector explains its position in the non-aseptic sector.

Table D summarises the variables used in the present analysis[155]:

TABLE D

Summary of Variables			
Var.	**Name of the Variable**	**Mean**	**Std. Deviation**
Y	T.Pak's m. share non-asep. (cartons)	48.52	23.85
X_1	T.Pak m.share aseptics (cartons)	80.17	23.44
X_2	T.Pak's m. share aseptics (machines)	91.21	12.33
X_3	T.Pak's prices Rex (machines)	123.3	20.25
X_4	T.Pak's prices aseptics (machines)	173.3	30.62
X_5	T.Pak's m. share non-asep. (machines)	54.8	18.61
X_6	Elopak's m. share (cartons)	27.81	12.88
X_7	Herfindahl index aseptics (cartons)	0.78	0.2
X_8	Herfindahl index non-asep. (cartons)	0.4	0.21

[154]See Bulow *et al.* [1985]. They expect a negative relation.

[155]Source: Annexes of the EC Commision Decision, 'Tetra Pak II', L 72/1, 24 July 1991.

The unrestricted[156] model is used as the starting point to study the explanatory power of some of the independent variables[157]. The model is initially specified as follows:

$$X_{8i} = \alpha + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_5 X_{5i} + \beta_7 X_{7i} + \epsilon_i$$
$$i = 1...12 \qquad \text{(II.11)}$$

where ϵ_i is distributed as a Normal(0,1).

In a first step of the analysis, a variable that gives global information about the non-aseptic sector is the Herfindalh index of that sector (variable X_{8i}) which is the dependent variable. The explanatory variables are: Tetra Pak's market share in the aseptic sector for machines (variable X_2), the prices charged by Tetra Pak for the non-aseptic Rex machines (X_3), Tetra Pak's market share in the non-aseptic sector for machines (X_5) and the Herfindahl index of the aseptic sector (X_7).

Results from this first model reflect more or less what one would have expected. That is, the explanatory variables that explain Tetra Pak's market share in the non-aseptic sector for cartons are Tetra Pak's market share in the non-aseptic sector for machines (X_5), prices charged by Tetra Pak for the Rex (non-aseptic) machines (X_3) and the Herfindahl index of the aseptic sector for cartons (X_7)[158].

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[156]The most general model includes all relevant variables for which there are data available.

[157]Since Tetra and Elopak compete in the non-aseptic sector, Elopak's market shares in the sector for cartons is negatively correlated, with ($\rho_{Y,X_6} = -1$), to Tetra's market share in the non-aseptic sector for cartons. This leads to the elimination of X_6.

[158]With $\hat{\beta}_3 = 0.0044$, $\hat{\beta}_5 = 0.006$ and $\hat{\beta}_7 = 0.533$.

However, it is remarkable to observe that the Herfindahl index is a censored dependent variable[159]. In particular, the minimum value of the Herfindahl index for an industry composed by n firms is not zero but the value of this index that would correspond to an industry that has n firms with equal market shares ($s_i = 1/\eta$, $i = 1...n$). For the analysis of a censored variable, it is necessary to apply a Tobit model[160].

Given that not all firms produce in all countries involved in the case[161], I take[162] $n = 5$ and, therefore, $H_m = 0.2$ is the lower bound of the Herfindahl index as the dependent variable of the model.

Different Tobit models have been tested in this analysis. The general formulation of this model is such that,

$$\begin{aligned} X^*_{6i} &= \beta' X_{ki} + \epsilon_i \\ X_{6i} &= 0.2 \text{ if } X_{6i} \leq 0.2 \\ X_{6i} &= X^*_{6i} \text{ if } X^*_{6i} > 0.2 \end{aligned} \qquad \text{(II.12)}$$

where X_{ki} is the vector of explanatory variables and β is the vector of parameters β_i which measures the marginal effect of each explanatory variable in the model.

The dependent variable is the Herfindahl index of the non-aseptic sector for cartons. I have also used as a dependent variable of the same model, the

[159]In the sense that values in a certain range are all reported as a single value.

[160]Conventional regression models fail to account for the qualitative difference between limit observation and nonlimit observations. See Greene [1993].

[161]See Appendix 2.

[162]The maximum number of firms supplying all countries.

transformed index[163] $H/(1-H)$,

As far as the significance of the explanatory variables is concerned, it is of interest to emphasise some of the results obtained. First, Tetra Pak's market share in the non-aseptic sector for machines (variable X_5) is invariably good in explaining the concentration degree of the non-aseptic sector. This is the case also for the prices charged by Tetra Pak for the non-aseptic Rex machines (X_3) and for the Herfindahl index in the aseptic sector for cartons (X_7). Therefore, results confirm what it was already obtained trough standard regression analysis. Moreover, the marginal effect that those variables have in the model is the highest within the set of all explanatory variables. In particular, $\beta_5 = 0.5$, $\beta_3 = 0.68$, $\beta_7 = 0.65$.

This can be considered as the first signal that the aseptic sector may explain the non-aseptic sector. However, it is still too general as a result. Going beyond this general result, I intend to focus on Tetra Pak and its position in the specific sector of non-aseptics. In this case, the unrestricted model becomes:

$$Y_i = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 X_{4i} + \beta_5 X_{5i} + \epsilon_i$$
$$i = 1...12 \qquad \text{(II.13)}$$

The additional explanatory variables are Tetra Pak's market share in the aseptic sector for cartons (X_1) and the prices charged by Tetra Pak for the aseptic machines (X_4).

However, although these variables are taken a priori as explanatory variables, there is a structural relationship between them. Therefore, it is necessary to test for the simultaneity bias of including variables X_1 to X_5. The

[163]In this case, the minimum value is equal to 0.25.

specification test devised by Hausman (1978) and later by Spencer and Berk (1981)[164] provides a method of testing for exogeneity in a single equation with more than one endogenous variable[165]. The test statistic is $w = 0.0001 < 3.84$ and, thus, the hypothesis of exogeneity is not rejected.

The matrix of correlation among the variables of this model leads me to the following remarks: first, prices charged by Tetra for the aseptic and non-aseptic machines are highly correlated ($\rho_{X_3,X_4} = 0.84$). This may be due to differences across countries and a consequent 'pricing to market'[166].

Second, there is a negative correlation between Tetra's market share and prices of machines ($\rho_{X_3,X_5} = -0.07$) in the non-aseptic sector and also a negative correlation of the corresponding variables, ($\rho_{X_2,X_4} = -0.1$), in the aseptic sector[167].

The estimation of the original model leads to the restricted model[168]:

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[164]They introduced a single-equation version of the Hausman test.

[165]The test is such that, under H_o: X_i is exogenous and, under under H_1: X_i is endogenous. The statistic is distributed as a χ^2 with one degree of freedom. See Greene [1993] for details.

[166]See Krugman [1986].

[167]As one would have expected, I find that prices for non-aseptic machines (Rex) and Tetra's market share in the aseptic sector for cartons are negatively correlated ($\rho_{X_1,X_3} = -0.38$), and that prices for aseptic machines are negatively correlated to Tetra's market share in the aseptic sector for cartons ($\rho_{X_1,X_4} = -0.3$).

[168]To test this, I apply a test of the overall significance of the regression excluding these variables. With a value of $F = 0.031 < F_5^3$, the elimination of X_1, X_4, and X_5 does not significantly decrease the explanatory power of the model.

$$Y_i = \alpha + \beta_2 X_{2i} + \beta_3 X_{3i} + \epsilon_i$$

$$i = 1...12 \qquad \text{(II.14)}$$

Table E summarises the estimates of the parameters and the corresponding t-statistics for the two models, the unrestricted and the restricted one.

TABLE E

	$\hat{\alpha}$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	R^2
	$(t_{\hat{\alpha}})$	$(t_{\hat{\beta}_1})$	$(t_{\hat{\beta}_2})$	$(t_{\hat{\beta}_3})$	$(t_{\hat{\beta}_4})$	$(t_{\hat{\beta}_5})$	SSR
Model 1	-156.23	0.345	0.6	0.72	0.02	0.53	0.7
	(-2.664)	(1.3)	(1.17)	(1.34)	(0.05)	(1.59)	1855.72
Model 2	-127.69	-	1.117	0.6	-	-	0.5
	(-2.198)	-	(2.44)	(2.163)	-	-	2774.6

As a result, Tetra Pak's market shares in the aseptic sector for machines and prices charged for non-aseptic machines seem to be the only variables which explain the market share of Tetra Pak in the non-aseptic sector for cartons. Both variables are negatively correlated[169] which may be considered a signal of the degree of substitutability between aseptic and non-aseptic machines. In this sense, the position of Tetra Pak in the sector of machines, aseptic and non-aseptic, explain Tetra's market share in the non-aseptic sector for cartons. This result, together with the fact that there is a positive correlation between Tetra Pak's market shares in the two sectors are, up to now, two indications that go in the line of the Commission's assertions. However, I believe that more information can be obtained from the data available.

[169] $\rho_{X_2,X_3} = -0.14$.

II.6.1 A Logit Model

In this section, I use a logit analysis[170] to empirically test the influence of a number of explanatory variables on the probability that Tetra Pak has a dominant position in the non-aseptic sector[171]. Given the information which is available, this is as far as an empirical analysis of the Tetra Pak case can go. I base my analysis on the report submitted by Tetra Pak to the European Commission[172].

Based on these data, the EC Commission concludes that Tetra Pak has a dominant position in the sector of non-aseptics and that[173]:

> "The data available in annexes 1.1 and 1.2 ilustrate not only the dominant position and even monopolistic of Tetra Pak in the aseptic sector, but also the first position that this group holds in the non-aseptic sector, in which it has a market share that can be considered by itself as a dominant position".

It is worth emphasising that these data show, according to the European Commission, how Tetra Pak, using its dominant position in the aseptic sector, also dominates the sector for non-aseptics. More specifically, the EC Commission afirms that[174]:

> "Tetra Pak has used the relation between the two sectors to abuse in the non-aseptic sector. This abuse would have never been possible if Tetra Pak

[170]Which is based on a qualitative response model in which the dependent variable is a discrete outcome. Conventional regression methods are inappropriate in these kind of models.

[171]The EC Commission Decision, 'Tetra Pak II', refers to both cartons and machines sold by Tetra Pak. However, I analyse this effect exclusively for the aseptic sector of cartons.

[172]See EC Commission Decisions, 'Tetra Pak I' [1988] and 'Tetra Pak II' [1991].

[173]'Tetra Pak II', p. 72/19.

[174]'Tetra Pak II', p. 72/22.

would not have a dominant position in the aseptic sector".

Therefore, I focus on the extent to which the aseptic sector explains the probability of a dominant position in the non-aseptic sector, holding constant other potentially relevant factors that might also affect the non-aseptic sector. Following the definition of dominant position used explicitly by the EC Commission, I consider that high market shares are enough as an evidence of a dominant position, and that this is the case of a market share of 50 per cent. Although this may appear as a partial hypothesis test, finding that there is no positive effect of the aseptic sector situation on the probability of Tetra Pak to be dominant in the non-aseptic sector, would contradict the decision taken by the EC Commission.

From the investigation of the EC Commission[175] I take the market shares of each of the firms that produce in both sectors, aseptic and non-aseptic. I use the Herfindahl-Hirschmann index as a measure of the market concentration for the aseptic sector[176]. I include instead the market share of Tetra Pak for the aseptic sector[177], Elopak's market share in the non-aseptic sector and prices charged by Tetra Pak in both sectors as explanatory variables[178], given that these are associated with the cited decision of the EC Commission.

[175]See Table D.

[176]In the work presented here, I measure this index as percentages. This variable is not used in the first logit-model proposed because it would lead to a problem of multicolinearity.

[177]Including cartons and machines.

[178]I include, as a relevant explanatory variable, the prices charged by Tetra Pak for the Rex machines which are considered by Elopak –in its accusation – to be sold at abusive prices.

The logit-model can be generalized as follows:

$$\Pi_i = \alpha + \sum_j \beta_j X_{ji}^{\bullet}$$
$$i = 1...12 \qquad \text{(II.15)}$$

where Π_i is the probability that Tetra Pak has a market share bigger or equal to 50 per cent in the non-aseptic sector in country i. X_{ji} refers to any explanatory variable j for country i. The qualitative dependent variable is binary taking the value '1' when Tetra Pak's market share in the non-aseptic sector is bigger or equal to 50 per cent, and the value '0' otherwise. Therefore, I use logit analysis which implies that the dependent variable is transformed as $ln[\Pi/(1-\Pi)]$.

Two different logit-models have been tested to analyse the factors that could determine whether or not Tetra Pak is dominant in the non-aseptic sector in one specific country. My aim is to test whether, with the data available, one may conclude or not – like the EC Commission did – that the firm under discussion is dominant in the non-aseptic sector due to its position in the aseptic one.

The first model[179] (model 3) analyses the effect of the level of concentration in the sector for aseptic products on the probability that Tetra is domi-

[179]A different logit model was tested to measure the influence of the position of Tetra Pak in the aseptic sector for cartons. The marginal effect on the dependent variable due to changes of 1 per cent in the Tetra Pak's market share in the aseptic sector is 0.25 per cent. This small but positive effect is an indicator of the positive correlation between both sectors. This, among other reasons, can be due to the fact that Tetra Pak is able to use the same technology in both sectors. Moreover, the estimated parameter is not significant, and the model explains only a 0.008 per cent of the dependent variable and the number of correct predictions is very low. As a result, I find that the market share of Tetra Pak in the aseptic sector can not be considered a good variable to explain the probability that the firm

nant in the non-aseptic sector. Table F shows the results of the estimation[180]:

TABLE F

Model 3				
Variable	Coefficient	Std. Error	Marginal Effect	Probability
Constant	-6.89	3.940	-	0.001
H.index	8.2	4.7	2.05	0.998

Note: H.index=Herfindahl index for cartons in the aseptic sector.

The effect that changes in the level of concentration of the aseptic sector have on the probability that Tetra Pak has a dominant position in the non-aseptic sector is positive and equal to the 2.05 per cent. An increase of 1 per cent in the concentration degree of the aseptic sector will result, with probability 0.5, in an increase of 2.05 per cent in the probability of Tetra Pak's dominant position in the non-aseptic sector. It is the level of concentration in the aseptic sector, and not just the position of Tetra which explains Tetra Pak's position in the related sector of non-aseptics.

There are three different measures to test the goodness of fit in this kind of models[181]:

1. The likelihood ratio test on the hypothesis $H_o : \beta_j = 0 \; \forall j$, as a measure of the joint significance of the parameters. The likelihood ratio is distributed

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has a dominant position in the non-aseptic sector, which is not what the EC Commission says.

[180]The marginal effect of each explanatory variable on the dependent variable is the maximum effect possible, i.e. when the probability is 0.5. The estimated value of the probability corresponds to the average value of the explanatory variable. This holds for the two models presented.

[181]See Maddala [1989] for further details on logit models.

as a χ-squared with k – the number of explanatory variables – degrees of freedom[182].

2. McFadden's pseudo $R^2 = 1 - logL_u/logL_r$, where L_u is the unrestricted likelihood funtion and L_r is the restricted one[183].

3. The proportion of correct predictions out of the total number of observations.

The goodness of fit in this model indicates that:

$$\chi^2(1) = 4.15$$

$$\text{McFadden's pseudo } R^2 = 0.25$$

$$\text{Number of correct predictions} = 10$$

The null hypothesis is rejected only at significance levels lower than 95 per cent. This means that $\hat{\beta}_1$ is not significantly different from zero at high levels of significance. The model explains a 25 per cent of the dependent qualitative variable. Although small, this positive effect would not have been expected if one were taking into account the relation of substitutability between the two sectors. As a result, the level of concentration is found to have some explanatory power on the dependent variable but the explanation remains partial.

The second logit-model (model 4) aims at explaining the position of Tetra Pak in the non-aseptic sector through variables that refer to Tetra in the aseptic sector. In particular, Tetra's market share in the aseptic sector (for

[182]This value has to be compared with the statistical value on the tables for the χ-squared distribution that corresponds to that specific number of degrees of freedom.

[183]In the sense that the unrestricted likelihood is maximised with respect to all the parameters, and the restricted likelihood is maximised with respect to α only.

machines and cartons separately) and the prices charged by Tetra for the machines in the same sector. To avoid problems of multicolinearity, the Herfindahl index is not included in this model[184]. Table G shows the results obtained from the estimation.

TABLE G

Model 4				
Variable	Coefficient	Std. Error	Marginal Effect	Probability
Constant	-288.12	5753	-	0
TP m.s. cartons (aseptic)	0.12	11.55	0.03	0.99
TP m.s. machines (aseptic)	2.31	61.55	0.6	1
TP prices for machines (aseptic)	0.33	5.6	0.08	1

The marginal effects are positive[185]. It can be concluded that the explanatory variables chosen in this model explain the evolution of the market share that Tetra Pak has in the non-aseptic market for cartons[186]. Furthermore, the three measures of the goodness of fit are:

$$\chi^2(3) = 16.3$$

McFadden's pseudo $R^2 = 0.99$

Number of correct predictions = 12

[184]The significance of this index, evident from model 3, is included in model 4 through Tetra Pak's market share in the aseptic sector.

[185]It is remarkable the significance of the marginal effect due to the market share of Tetra in the aseptic sector for machines.

[186]Including Tetra Pak's prices for the Rex (non-aseptic) machines as an explanatory variable, does not add any more information.

The null hypothesis is rejected at all significance levels. This means that $\hat{\beta}_1, \hat{\beta}_2, \hat{\beta}_4$ are significantly different from zero. Furthermore, the model explains 99 per cent of the probability of dominance of Tetra Pak in the non-aseptic sector. This does not confirm completely the Commission's claims concerning the effect of Tetra Pak's high market share in the aseptic sector on its market share in the sector for non-aseptic packaging. Other effects apart from that produced by the market share are also fundamental. This happens in particular with the prices for aseptic machines. It may be that the prices that Tetra charges for these machines are also the result of its dominance in the aseptic sector. Of course, if not dominance, other characteristics of Tetra's behaviour in the aseptic sector – which may also, in an implicit way, have to do with dominance – determine its dominance in the sector for non-aseptics. Nevertheless, the relation between the two sectors should be treated and modelled in a rigorous way.

II.6.2 Conclusions

A first attempt to study empirically the Tetra Pak case leads to the conclusion that, in general, prices charged by Tetra Pak for the non-aseptic Rex machines, Tetra Pak's market share for the aseptic machines and the concentration level of the aseptic sector for cartons, are a good measure of the concentration level of the non-aseptic sector of cartons.

In an analysis that focuses on Tetra's position in the two sectors, I find that Tetra Pak's market shares in the aseptic sector for machines and prices charged for non-aseptic machines are the only variables that could explain Tetra's market share in the non-aseptic sector for cartons. The dominant position of Tetra in the aseptic sector for cartons seems to have no direct

effect in its position in the non-aseptic sector.

I have used a logit approach. The data show that Tetra Pak is likely to be dominant in the non-aseptic sector, because of its position in the aseptic sector and this is expressed in the price level of aseptic machines, the market share for cartons and machines in the aseptic sector, as opposed to the market share in the aseptic sector of cartons alone.

On the other hand and given the fact that, in the absence of any production relations between the aseptic and non-aseptic sectors, a negative relation between the market shares of Tetra Pak in both sectors would have been expected, a positive correlation between the market share of Tetra Pak for aseptics and the one for non-aseptics can be considered either as a sign of anti-competitive behaviour in the part of Tetra or a signal of the existence of some production relation between the two types of product (aseptic-non-aseptic).

As a result of the logit-analysis of the data presented by Tetra Pak to the EC Commission, I have found that[187] the Commission may have reached a correct conclusion. On one hand, Tetra Pak is likely to have behaved anti-competitively. On the other hand, market shares in the aseptic sector and prices charged for machines to produce aseptics are sufficient to explain the probability that Tetra Pak has a dominant position in the sector for non-aseptic products and, perhaps, to conclude that dominance permits Tetra Pak to dominate also the non-aseptic sector.

[187]In the sense that it is a legal study with the use of economic concepts.

II.7 Final Conclusions

A more correct notion of relevant market in the Tetra Pak case would include a market for two different varieties of a differentiated product, the aseptic and the non-aseptic. Under this definition, I have studied the Tetra Pak case and, more specifically, the role of the relation between the two different sectors, aseptic and non-aseptic, in determining Tetra Pak's dominance in the non-aseptic sector. The European Commission used the relation between these two sectors to prove that Tetra Pak had a dominant position in the non-aseptic assuming that Tetra has a dominant position in the sector of aseptics. The factors that, in the literature, characterise a dominant firm do not fit with the ones that define Tetra Pak's position in the non-aseptic sector. Therefore, it would be incorrect to consider Tetra's market share in that sector as the one of a dominant firm.

In a first empirical regression-analysis of the data available from 'Tetra Pak II' the positive correlation between Tetra Pak's market shares in the two sectors confirms the Commission's assertion that Tetra's market share in the non-aseptic sector is a result of its position in the aseptic sector. Going beyond that, I have proposed a logit-analysis which, based on the data available from the Commission's investigations, shows that the market shares of Tetra in the sector for aseptic cartons and machines, as well as the prices charged by Tetra for the aseptic machines, are positively correlated to the probability that Tetra Pak dominates the non-aseptic sector. However, dominance does not necessarily imply an abuse. Other factors like demand and supply conditions should be considered. For example, the possibility of a production relation between the two types of products has been systematically ignored. Therefore, one cannot conclude with certainty that the Commission is right

to consider the relation between Tetra Pak's shares in the two sectors as the result of abuse of a dominant position.

Further empirical analysis is called for. On this purpose, the Commission should be provided with all information necessary.

II.8 Appendix: Figures and Data

II.8.1 Figures

Figure 1 compares Tetra Pak's market shares in the two different sectors, the aseptic and the non-aseptic[188]. To construct the two curves, I have used the information given in the EC Commission Decision 'Tetra Pak II', p. 72/20 and 72/10:

On one hand, according to the Commission, if one takes into consideration the global sector of carton packaging for liquid food, i.e. the aseptic *and* the non-aseptic sectors, the market share of Tetra Pak was, chronologically, 60% to 65% in 1976, 65% to 70% in 1980, 70% to 75% in 1985 and 78% in 1987. On the other hand, Tetra's market share of the Italian market for non-aseptic packaging was 79% in 1977, 70% in 1981, 76.3

Based on this information, I have created the two series of data contained in Table H that correspond to Tetra Pak's market share in the two sectors and that are showed in Figure 11.

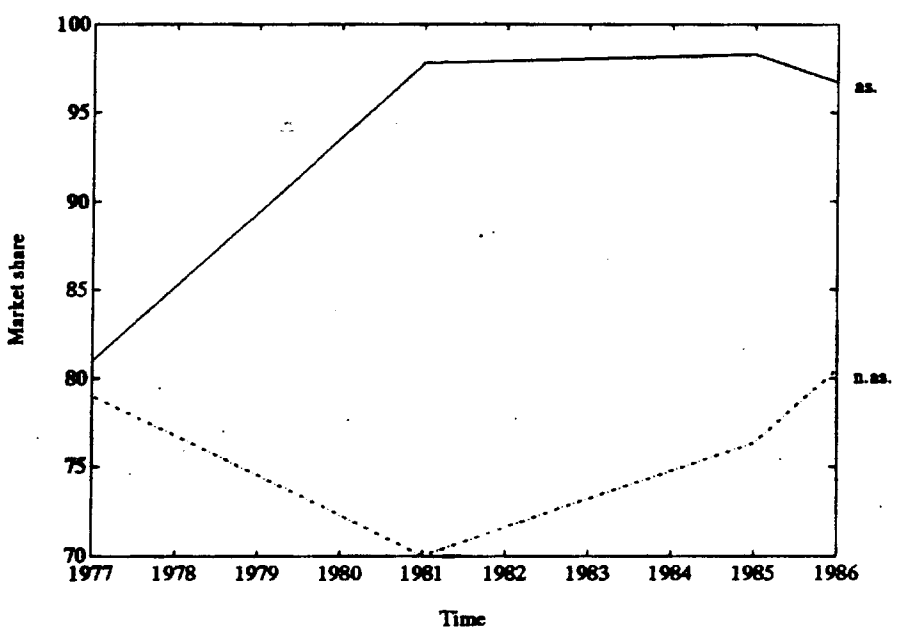
TABLE H

Year	Tetra aseptic	Tetra non-aseptic
1977	81	79
1981	97.8	70
1985	98.3	76.3
1986	96.7	80.5

Note: market shares are expressed in percentages.

[188]The data used are referred to Italy, since it was in this country that the Tetra Pak case started.

Figure II.11: **Tetra Pak's market shares**



II.8.2 The Data

The data showed in next Table K are referred to 1985.

TABLE K

TABLE of DATA												
Variable	**B**	**DK**	**F**	**D**	**GR**	**EI**	**I**	**NL**	**P**	**SP**	**UK**	**LU**
MSTas	83.4	100	93.6	81.3	56.9	23.1	98.2	57.4	100	100	84.7	83.4
MSTna	29.6	34.5	55.8	41.9	16.7	69.2	76.3	32.1	100	55.9	40.6	29.6
MSPKLas	16.6	0	6.4	18.7	43.1	76.9	1.8	42.6	0	0	15.3	16.6
MSE	38.02	35.4	23.9	31.4	44.9	16.63	12.8	36.7	0	23.8	32.1	38.02
MSPKLna	15.5	14.4	9.7	12.8	18.3	6.8	5.2	14.94	0	9.7	13.1	15.5
MSS-P	9.9	9.2	6.2	8.1	11.66	4.3	3.3	9.5	0	6.2	8.3	9.9
MSM-E	3.5	3.3	2.2	2.9	4.17	1.54	1.2	3.4	0	2.2	3	3.5
MSV-M	0.7	0.65	0.44	0.58	0.83	0.31	0.24	0.68	0	0.44	0.6	0.7
MSOna	2.78	2.55	1.76	2.29	3.33	1.22	0.96	2.68	0	1.76	2.3	2.78
MSTas(m)	92.1	100	95.2	82	83.3	100	98.6	57.5	100	100	93.7	92.1
MSTna(m)	75	34.8	37.7	43.6	44.4	69.3	77.4	37.5	80	46.7	36.2	75
PRex	100	100	158.5	133	125	151	129	136	128	119	100	100
PMas	153	100	214	189	169	206	180	185.5	183	194	153	153
Has	0.72	1	0.88	0.69	0.51	0.64	0.96	0.51	1	1	0.74	0.72
Hnas	0.268	0.275	0.38	0.3	0.28	0.51	0.6	0.27	0.99	0.38	0.29	0.268

Source: Annexes of the EC Commision Decision, 'Tetra Pak II', L 72/1, 24 July 1991.

The columns correspond to the 12 countries that belong to the European Community. Market shares are measured in percentages. Prices are indexes calculated after their conversion in ecus[189]. The variables are:

MSTas: Tetra Pak's market share in the aseptic sector for cartons.

[189]Index 100 = Member State with the lower prices.

MSTna: Tetra Pak's market share in the non-aseptic sector for cartons.

MSPKLas: PKL's market market share in the aseptic sector for cartons.

MSE : Elopak's market share in the non-aseptic sector for cartons.

MSPKLna: PKL's market share in the carton's non-aseptic sector.

MSS-P : Shonw Packing's market share (non-aseptic sector).

MSM-E : Mono-Emballage's market share (non-aseptic sector).

MSV-M : Van-Mierlo's market share (non-aseptic sector).

MSOna : Others' market share in the non-aseptic sector for cartons.

MSTas(m) : Tetra Pak's market share in the aseptic sector for machines.

MSTna(m) : Tetra Pak's market share in the non-aseptic sector for machines.

PRex : Prices charged by Tetra for the Rex machines (non-aseptic).

PMas : Prices charged by Tetra for the machines for aseptic cartons.

Has : Herfindahl index for the aseptic sector for cartons.

Hnas : Herfindahl index for the non aseptic sector for cartons.

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